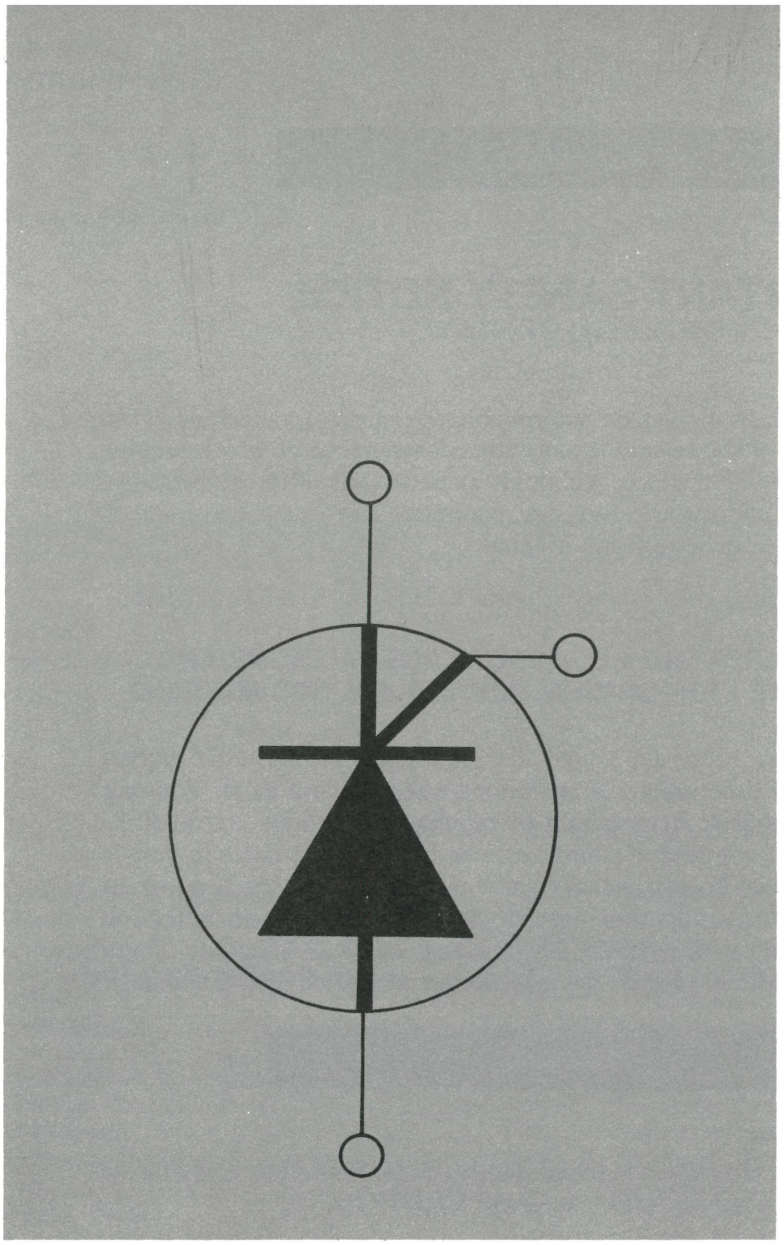
FORM NO. SENB8038-01

FOR USE IN SERVICE MANUAL:
M20, M25, MC30 LIFT TRUCKS,
REG01595



SYSTEMS OPERATION
TESTING AND ADJUSTING
SPECIFICATIONS

400 SubCon Systems

M20, M25, MC30 SCR CONTROL SYSTEM

FOR

SERIAL NUMBERS
42W1-UP
43W1-UP

⚠ WARNING

IMPORTANT SAFETY NOTICE

Proper repair is important to the safe and reliable operation of a machine. This Service Manual outlines basic recommended procedures, some of which require special tools, devices or work methods. Although not necessarily all inclusive, a list of additional skills, precautions and knowledge required to safely perform repairs is provided in the SAFETY section of this Manual.

Improper repair procedures can be dangerous and could result in injury or death.

READ AND UNDERSTAND ALL SAFETY PRECAUTIONS AND WARNINGS BEFORE PERFORMING REPAIRS ON THIS MACHINE

Basic safety precautions, skills and knowledge are listed in the SAFETY section of this Manual and in the descriptions of operations where hazards exist. Warning labels have also been put on the machine to provide instructions and identify specific hazards which if not heeded could cause bodily injury or death to you or other persons. These labels identify hazards which may not be apparent to a trained mechanic. There are many potential hazards during repair for an untrained mechanic and there is no way to label the machine against all such hazards. These warnings in the Service Manual and on the machine are identified by this symbol:

⚠ WARNING

Operations that may result only in machine damage are identified by labels on the machine and in the Service Manual by the word **CAUTION**.

Caterpillar cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this Manual are therefore not all inclusive. If a procedure, tool, device or work method not specifically recommended by Caterpillar is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the machine will not be damaged or made unsafe by the procedures you choose.

IMPORTANT

The information, specifications and illustrations in this book are on the basis of information available at the time it was written. The specifications, torques, pressures of operation, measurements, adjustments, illustrations and other items can change at any time. These changes can effect the service given to the product. Get the complete and most current information before you start any job. Caterpillar Dealers have the most current information which is available. For a list of the most current modules and form numbers available for each Service Manual, see the SERVICE MANUAL CONTENTS MICROFICHE REG1139F.

NOTE: This book has been completely changed from the former issue.

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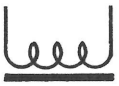
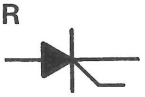
ELECTRIC NAMES AND DEFINITIONS

To fully understand how the THYRISTOR CONTROL SYSTEM operates, one will have to learn the meaning of the electric names used in this manual. Some of these names and descriptions are given here:

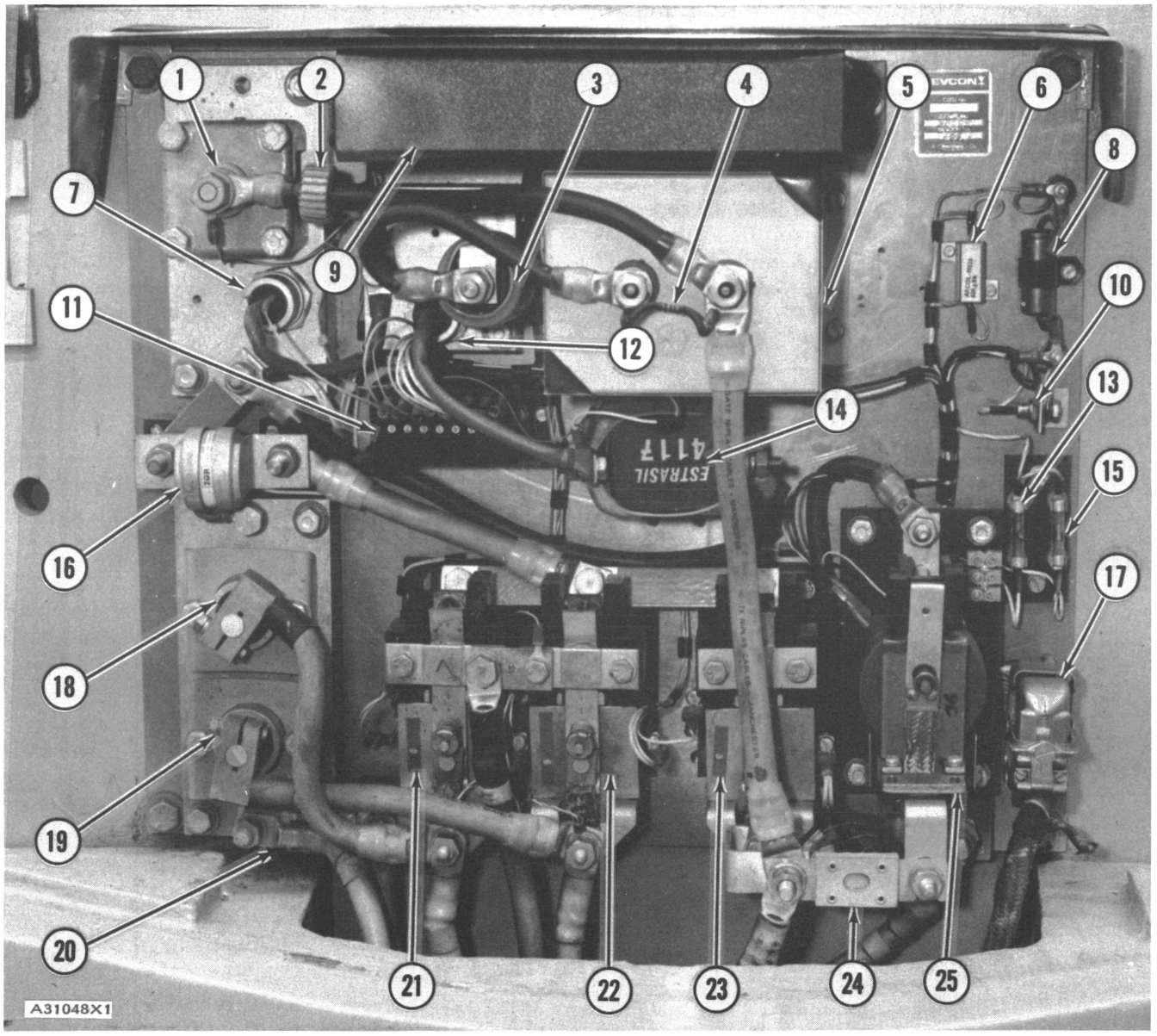
NAME-SYMBOL	DESCRIPTION
Ammeter	An electric meter used to measure current flow in amperes. Ammeter is often used with an Ammeter Shunt. Ammeter (or shunt) should always be in series with the circuit.
Anode	The positive end of a semiconductor.
Armature	The rotating part of an electric motor or generator.
Brush	The conductor, normally a block of carbon, that makes sliding contact between the stationary and moving part of the motor or generator.
Bus Bar	A heavy electrical conductor to which other smaller wires are connected.
Capacitor	Device used to store electrical energy for short periods of time.
Cathode	The negative end of a semiconductor.
Coil	A number of spiral turns of wire.
Circuit	The path followed by an electrical current.
Commutator	An armature component used to send current from the brushes to the wires in the coils of the armature.

NAME-SYMBOL	DESCRIPTION
Conductor	Any material that will pass an electric current.
Contact	The junction of two electric conductors through which a current flows.
Contactor Coil	An electromagnet used to close and open contacts.
Continuity	That description given to a circuit when it is complete.
Current	The flow or movement of electricity in a complete circuit.
Diode	A semiconductor that will let current flow in only one direction.
Discharge	The releasing of current from an electric component.
Direct Current	An electric current flowing in only one direction.
Electro Magnet	A magnet that gets its characteristics from the flow of current through a coil of wire around a core of soft iron.
Field Windings	The coils that give the magnetizing force in motors, generators and alternators.
Fuse	A protection unit that will open when current is higher than normal for a period of time.
Gate	A control element that uses a pulse to turn on a silicon controlled rectifier (Thyristor).

NAME-SYMBOL	DESCRIPTION
Heat Sink	A mounting frame used for semiconductor cooling.
Induction	The process of causing current flow by moving a magnetic field across a conductor.
Inductor Coil 	A coil which creates a magnetic field when current flows through it. Addition of iron in the core increases the strength of the magnetic field.
Logic Unit (Module)	The unit having electronic components and circuits which control the operation of the other components.
Ohmmeter	An electric meter used to directly measure resistance.
Overload	A flow of current larger than the rated capacity of an electric unit.
Plugging	The controlled electric stopping of the lift truck.
Potentiometer	A resistor equipped with an adjustable centre tap connected across a voltage supply to enable an intermediate voltage to be selected.
Pulse	Electric current flowing for a short period of time.
Resistor	A unit that has electric resistance and is used in an electric circuit for reduction of current flow or voltage
Saturation	The condition in an electric circuit where an increase in current makes no increase in magnetism.
SCR 	Silicon Controlled Rectifier. An electrically operated switch often called a Thyristor.

NAME-SYMBOL	DESCRIPTION
Self-Induction	The process by which a circuit makes a voltage by using its own magnetic field.
Series Wound	A motor or generator in which the armature is connected in series with the field windings.
Semi-conductors	An electrical device which acts as a conductor under certain conditions, and as a non-conductor or an insulator under other conditions.
Short Circuit	A circuit of insignificant resistance.
Shunt	A connection between two points in an electrical circuit which gives an alternate path of current flow.
Suppression Unit	The unit with electronic circuits which has control of gate leads for Thyristors TH2 and TH3.
Switch	An electric unit for making, breaking or changing a connection in an electric circuit.
Thermal Protector (Thermistor)	An electric unit that causes a reduction in current flow in a circuit, through the increase of resistance, when temperatures go higher than a specific level.
Thyristor (SCR)	An electrically operated switch that has no moving parts and lets current flow in one direction only after a pulse is supplied to the gate. Switching on a thyristor in this manner is called firing.
Thyrostop	The unit with electronic circuits which control pump contactor operation.
Voltmeter	An instrument for measuring electric force.

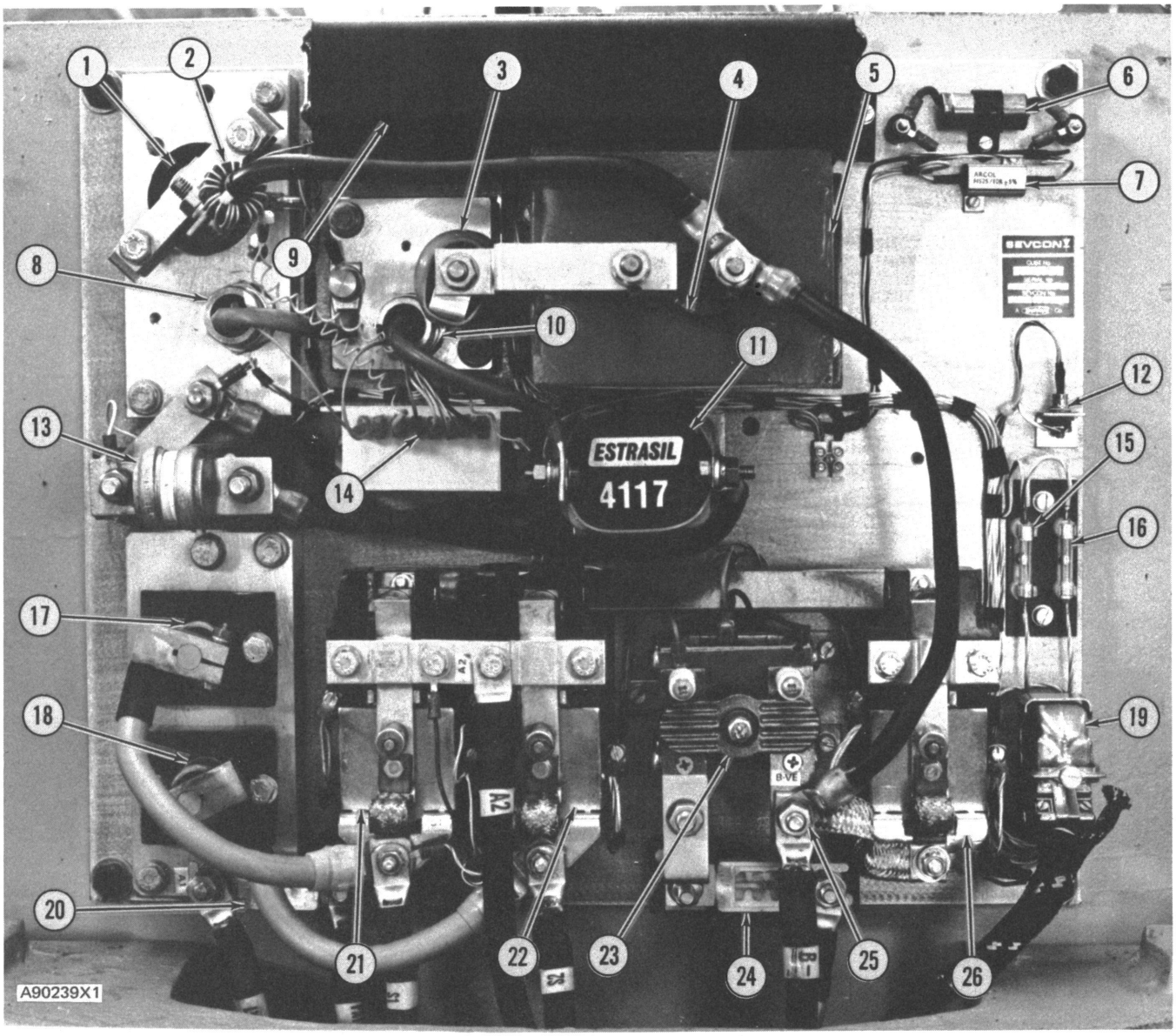
LOCATION OF COMPONENTS ON THE CONTROL PANEL



SCR CONTROL PANEL (EARLIER MODELS)

1. Thyristor No. 1.
2. L3.
3. L2.
4. R87 (discharge resistor).
5. C19.
6. R80.
7. Thyristor 2.
8. C23.
9. Logic unit (cover).
10. D40.
11. Thyristor suppression unit.
12. Thyristor 3.
13. Horn fuse (5A).
14. L1.
15. Control fuse (5A).
16. Thyristor fuse.
17. 18-way panel connector.
18. D41.
19. D42.
20. Traction motor fuse.
21. Forward contactor.
22. Reverse contactor.
23. Bypass contactor.
24. Pump motor fuse.
25. Pump contactor.

LOCATION OF COMPONENTS ON THE CONTROL PANEL



SCR CONTROL PANEL (CURRENT MODELS)

1. Thyristor No. 1.
2. L3.
3. L2.
4. R87 (discharge resistor).
5. C19.
6. C23.
7. R80.
8. Thyristor 2.
9. Logic unit (cover).
10. Thyristor 3.
11. Coil L1.
12. Diode D40.
13. Thyristor fuse.
14. Thyristor suppression unit.
15. Horn fuse (5A).
16. Control fuse (5A).
17. Diode D41.
18. Diode D42.
19. 18-way panel connector.
20. Traction motor fuse.
21. Forward contactor.
22. Reverse contactor.
23. Pump contactor (HB).
24. Hydraulic pump motor fuse.
25. Battery negative (B—) terminal.
26. Bypass contactor.

NOTE: The Thyrostop (when equipped) is installed under the pump contactor (23).

SYSTEMS OPERATION

GENERAL INFORMATION

Operation and control of the traction and hydraulic pump motors is provided with the SCR Control System. The system provides smooth speed control up to approximately 90% full speed. Full speed is obtained by closure of the Bypass Contactor. The SCR Control System has a "failure protection" circuit and also has protection against excessive current and temperature. A plugging control circuit is provided which gives constant braking torque irrespective of truck speed if the accelerator pedal is not moved (kept activated) during plugging. The degree of plugging can be varied, however, depending on how far the accelerator is depressed.

A detailed description of each circuit with a circuit diagram follows:

NOTE: The complete wiring diagram and schematics are in the fold-out pages in back of this book. The first fold-out is a complete schematic of the control system including the Logic Unit circuitry. An effort has been made to explain the function of the components inside the Logic Unit in relation to the different circuits.

LOGIC UNIT (MODULE)

This is an electronic circuit board which has control of eight distinct functions. Any malfunction of it will require repair or a replacement.

A list of the circuits in the Logic Unit is given in the chart that follows:

Circuits

CIRCUIT	PURPOSE OF THE CIRCUIT
1. Stabilized power supplies.	Gives power to the 9 volt and the 18 volt stabilized rails.
2. Contactor control circuits.	Controls the operation of the Forward, the Reverse, and the Bypass contactors.
3. On oscillator.	Source of pulses which activate Thyristor 1 (TH1).
4. Speed control.	Controls the frequency of the pulses to TH1.
5. Acceleration control.	Controls the rate of the increase in pulsing.
6. Current limit.	Keeps the motor current below the set limit during pulsing.
7. Anti-plugging.	Makes the decrease in truck speed smooth during plugging.
8. Failure protection circuit.	Checks "TH1 ON TIME" and opens F and R contactors if "ON TIME" is too long.

Connections To The Logic Unit

PIN	PURPOSE OF THE CONNECTION
1	9 volt supply to VR1 in Foot Control Unit.
2	36 volt supply.
4	18 volt supply to VR1 in Foot Control Unit.
7	36 volt supply to FS2.
8 and 10	Failure protection inhibition.
9 and 11	36 volt supply to the Forward, the Reverse, and the Bypass contactor control circuits.
12	Connection to VR1 wiper in Foot Control Unit.
13	Connection from Forward and Reverse contactor coils to control thyristor in Logic Unit.
15	Connection from Bypass contactor coil to control thyristor in Logic Unit.
17	Connection to Bypass contactor coil.
18	Connection from TH1 anode.
19	Connection to Battery negative —ve.
21	Connection to TH1 gate.
23 and 24	Input to plugging control circuit.

COMMUTATION CIRCUIT

Basic Description

1. If Forward or Reverse Contactor closes, the anodes of TH1 and TH2 are at positive battery voltage. Part of the current goes through coil L1 to the firing circuit of TH2 whose cathode is held to a negative potential because of the charge of capacitor C19.

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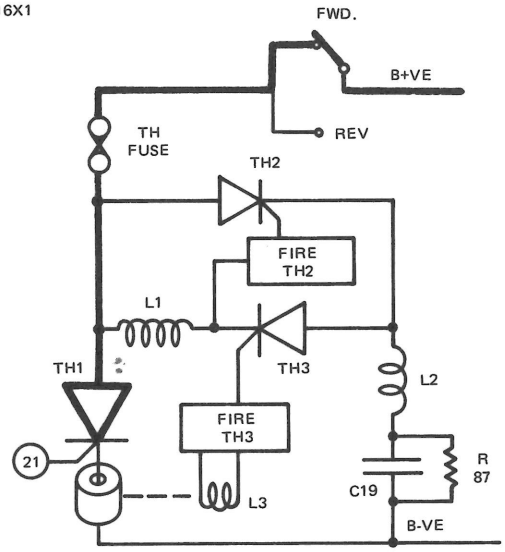
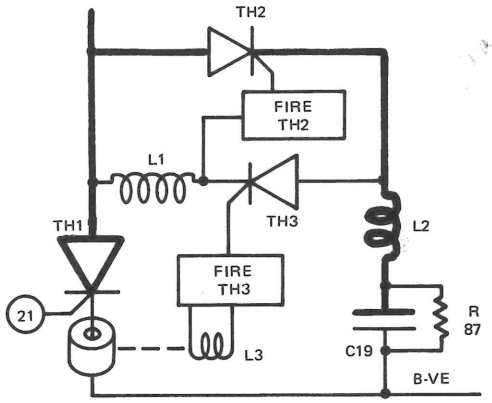


CIRCUIT TO FIRE THYRISTOR TH2

2. When TH2 is fired (turned on), C19 will charge by way of the inductance of coil L2. As soon as the charging current falls below the holding level of TH2, it will turn off. Thyristor TH1 is now ready to be fired by Pin 21 according to the signal of VR1, the potentiometer in the foot pedal unit, which will activate the ON oscillator circuit.



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CAPACITOR C19 CHARGED REVERSE (THYRISTOR TH2 "TURNS ON"; TH1 READY FOR "TURN ON")

3. When TH1 is conducting, current will flow through the traction, motor back to battery negative. This is the 'on time' for thyristor TH1 which is a pulse. With a very short time delay, the current induced in the ferrite (round with hole in center) core coil L3 will fire 'turn on' TH3. Capacitor C19 will discharge through L2, TH3, L1 and TH1. As soon as the current is below the holding level of TH3, it switches OFF. Full reverse capacitor voltage will be at the cathode of TH2, which will be fired immediately. The surge into capacitor C19 will draw away the current from the anode of TH1 and turn it OFF. Another cycle can now begin.

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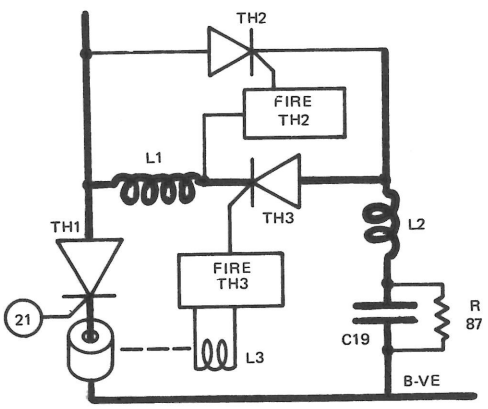
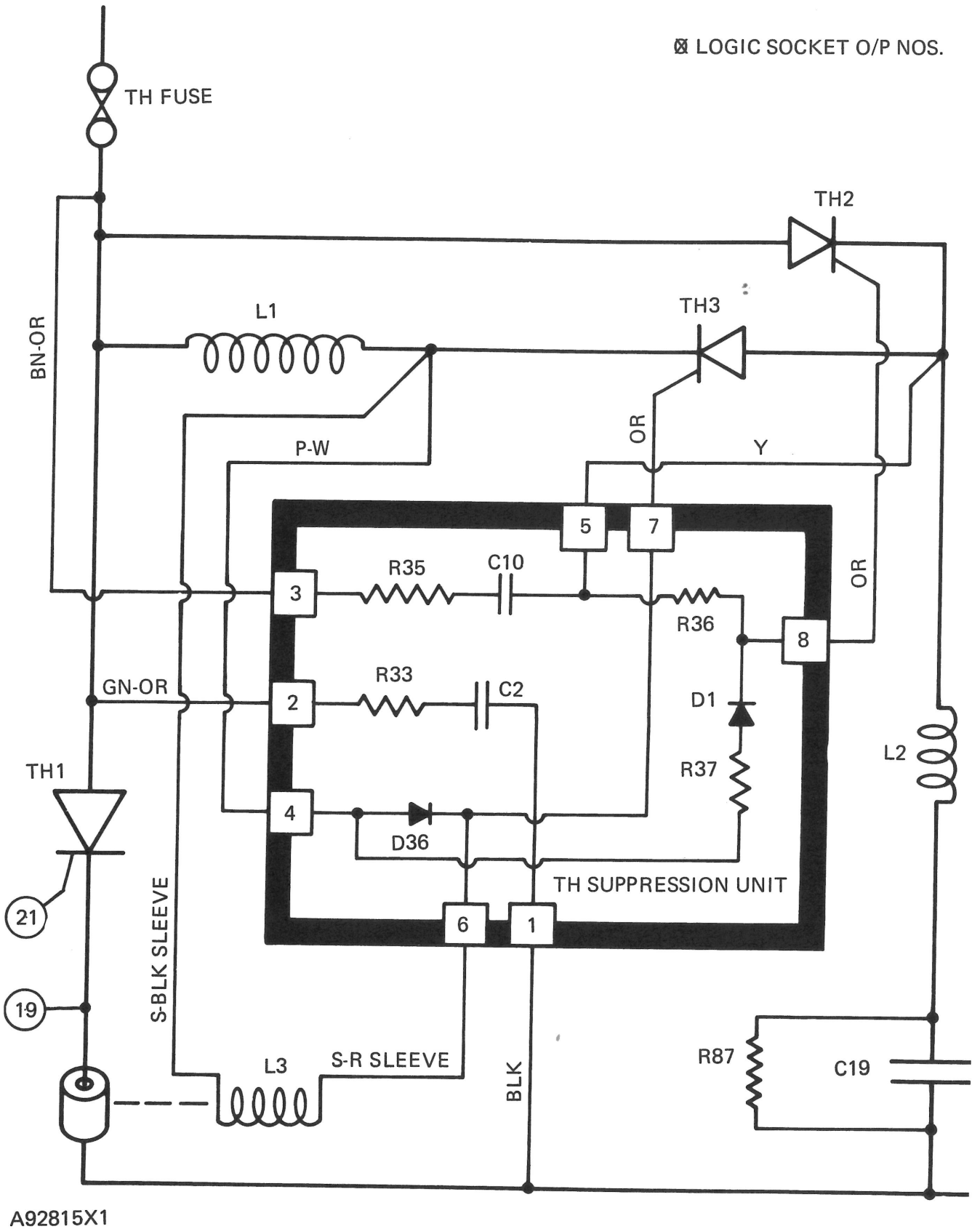


THYRISTORS TH1 AND TH3 "ON," READY FOR "TURN OFF"



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COMMUTATION CIRCUIT

Description of Sequences

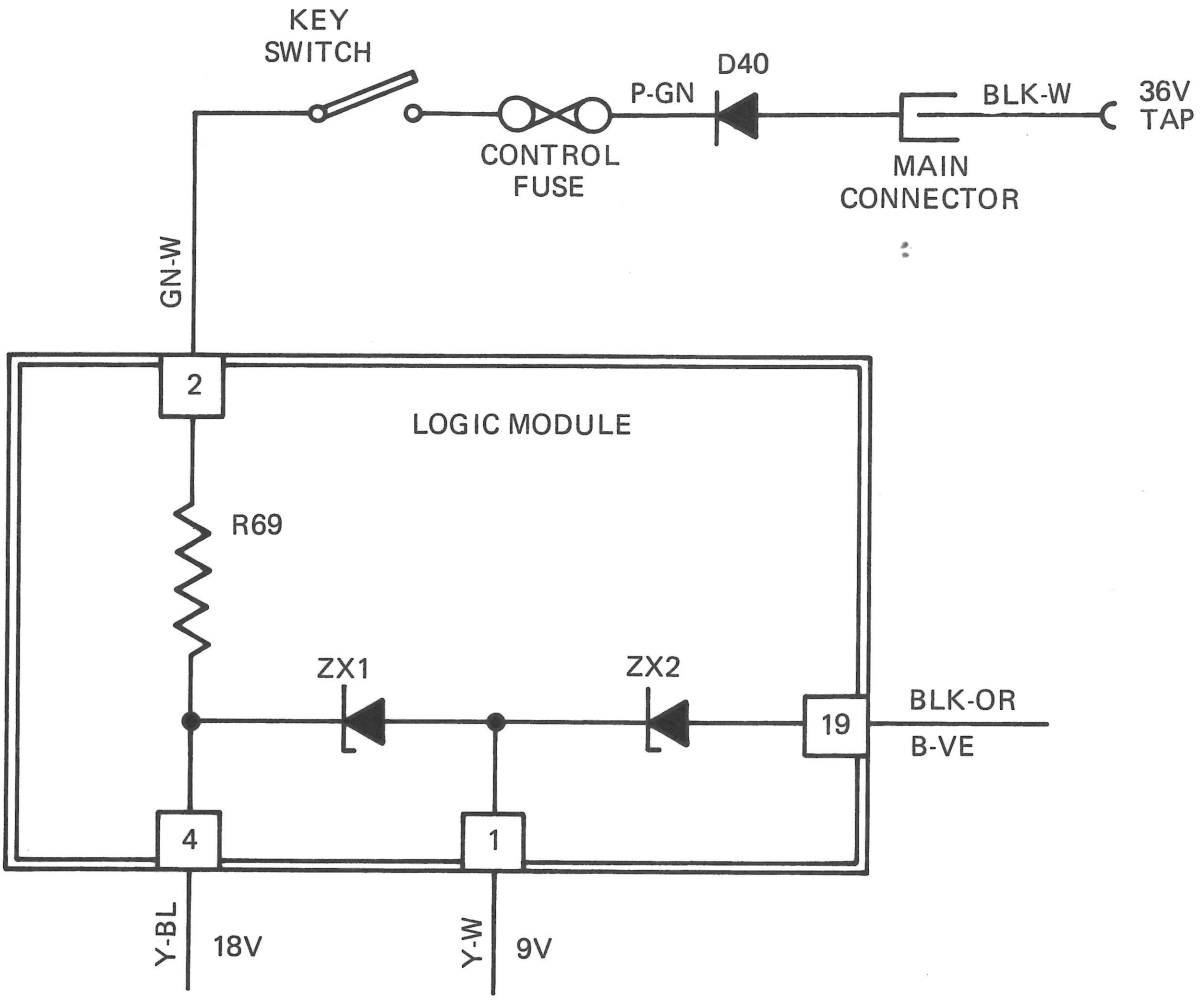
a) Preparation of the Commutation Circuit.

1. Direction contactor closes for the first time, to supply battery volts to anodes of thyristors TH1 and TH2.
2. The voltage drop across R36 will turn on TH2. Resistor R36 is part of a voltage divider that consists of R37, D1 and R36.
3. When TH2 is conducting current, capacitor C19 will charge up to battery voltage. The current will pass through the drive motor, TH fuse, TH2 and L2. The inductor L2 is in the circuit to control the rate of current rise through TH2.
4. As C19 is close to battery volts, charging current will reduce beyond the holding level of TH2 and it will 'turn off.'
5. Now the commutation circuit is ready to receive a gate firing signal to TH1 by way of pin 21 from the Logic Module.

b) Commutation Circuit in Action.

1. With C19 in a forward charge, TH1 gets a gate firing signal by way of pin 21. TH1 will turn on.
2. Current will flow from battery positive (+VE) through the motor, TH Fuse, TH1 and back to battery negative (−VE). This is the 'on time' of a pulse for TH1. As the current is now effective in the traction motor, the voltage across TH1 will be between 1 and 2 volts.
3. The current flowing through the cathode of TH1 will build up a magnetic field around the cable. The toroidal coil L3 positioned around this cable will create a secondary pulse according to the transformer effect. This pulse will turn on TH3.
4. When TH3 is 'turned on', C19 will discharge by way of L2, TH3, L1 and TH1. As the discharge time is very short, it will quickly build up a smaller magnetic field around L2 and a stronger one around L1. When C19 is discharged current flow stops. The induced current of the coil L2 will be quick enough to keep TH3 conducting. The strong magnetic field around L1 will induce a current and charge up C19 in the reverse direction to approximately 80% of the forward charge.
5. When the induced current flow stops, TH3 will 'turn off'. The full reverse voltage will appear across the voltage divider (R37, D1 and R36). The gate of TH2 gets positive in respect to its cathode and TH2 will 'turn on' immediately.
6. As TH2 is 'turned on', the voltage at the anode of TH1 will fall to the negative voltage of C19. TH1 will then 'turn off' as soon as its anode is negative in respect to its cathode.
7. TH2 continues to conduct until C19 is again charged in the forward direction. When C19 reaches battery voltage, TH2 will 'turn off'. The situation in the circuit will be the same until another gate signal is sent to 'turn on' TH1 and another cycle will repeat itself.

ACTIVATING CIRCUIT



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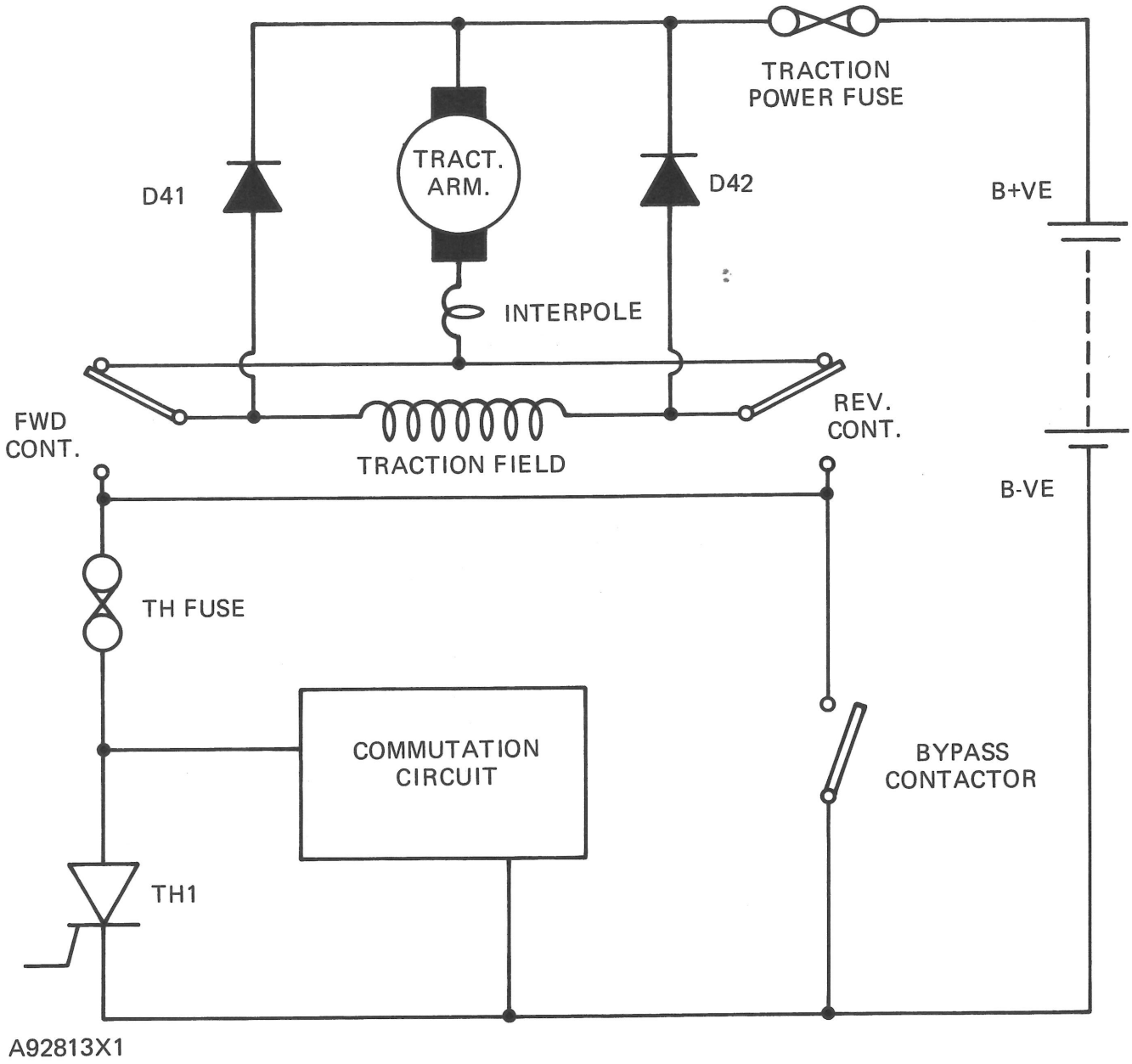
ACTIVATING CIRCUIT

The activating circuit gives power for regulation of current flow to all electrical controls and the Logic Unit Module.

A 36 volt tap is always available for the activating circuit regardless of the truck's battery voltage. The two zener diodes (ZX1, ZX2) make sure the voltage inside the Logic Module is stabilized and divided (9 volt positive, 9 volt negative) which is used to operate the different transistors and thyristors.

The circuit will have operation when the battery is connected and the key switch is 'turned on'.

POWER CIRCUIT



POWER CIRCUIT

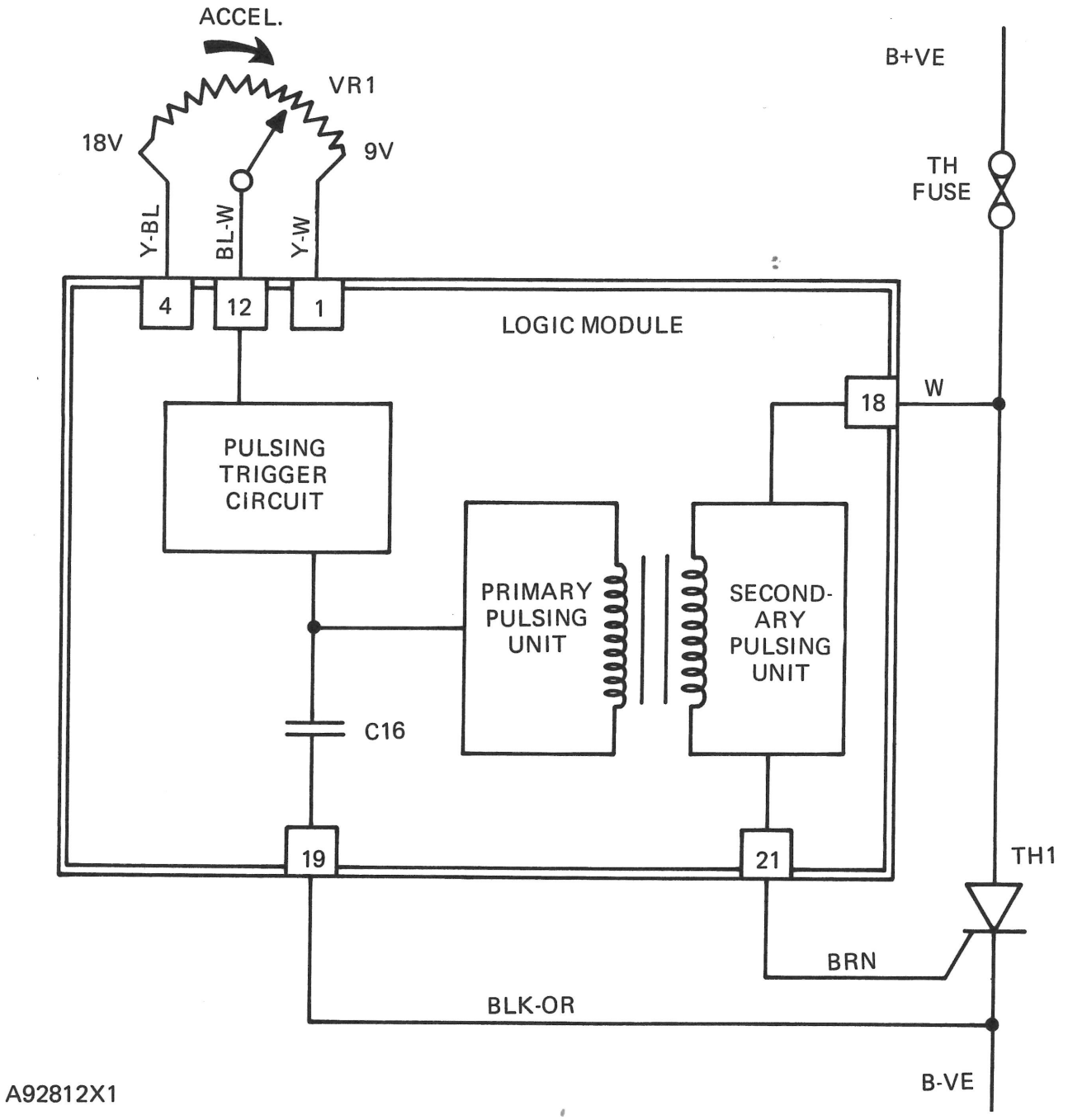
The power circuit takes current through the traction motor armature and through the forward and reverse contactors and the motor field. After this path, current has two possible paths to flow, they are:

1. To control speed, we pass thyristor TH1 with pulsing current up to about 90% of travel speed.

   The pulsing current is controlled by the ON-oscillator circuit in the Logic Module. When TH1 is 'turned on', the commutation circuit makes a pulse by itself, as it is a self continuing type thyristor control system.

2. When the pre-set pulsing level is reached, the bypass contactor will close and draw full power from the battery, which gives maximum travel speed. The engagement of the bypass contactor will stop TH1 operation at the same time.

PULSING CIRCUIT

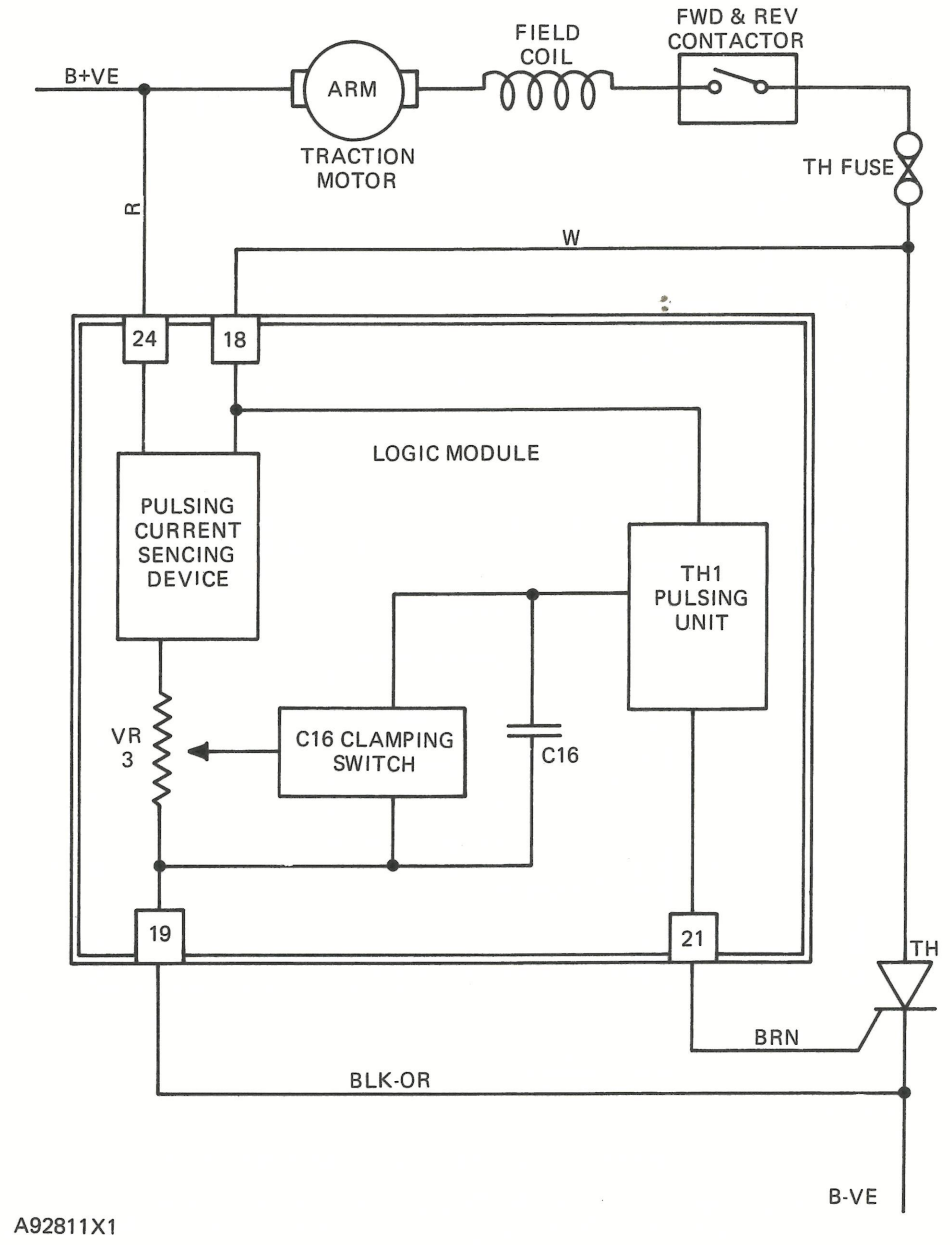


PULSING CIRCUIT

The voltage at pin 12 is determined by the position of the foot pedal, and it helps control the pulsing trigger circuit. The voltage will be 18 volts for minimum pulsing and 9 volts for maximum pulsing. If the foot pedal is activated, capacitor C16 gets a charging current; when it reaches a specific voltage level, the primary pulsing unit creates a pulse. The secondary pulsing unit transfers this pulse into a signal to 'turn on' TH1. This separation is necessary because the secondary pulsing unit is connected to TH1 anode and senses battery voltage while the remainder of the Logic Module is at a lower voltage.

The pulsing frequency depends on the amount of current the pulsing trigger circuit sends to capacitor C16. With a lower current it takes more time to charge C16, and this will extend the 'off time' of TH1, while the 'on time' is a constant of about 1.5 milliseconds.

CURRENT LIMIT CIRCUIT



CURRENT — LIMIT CIRCUIT

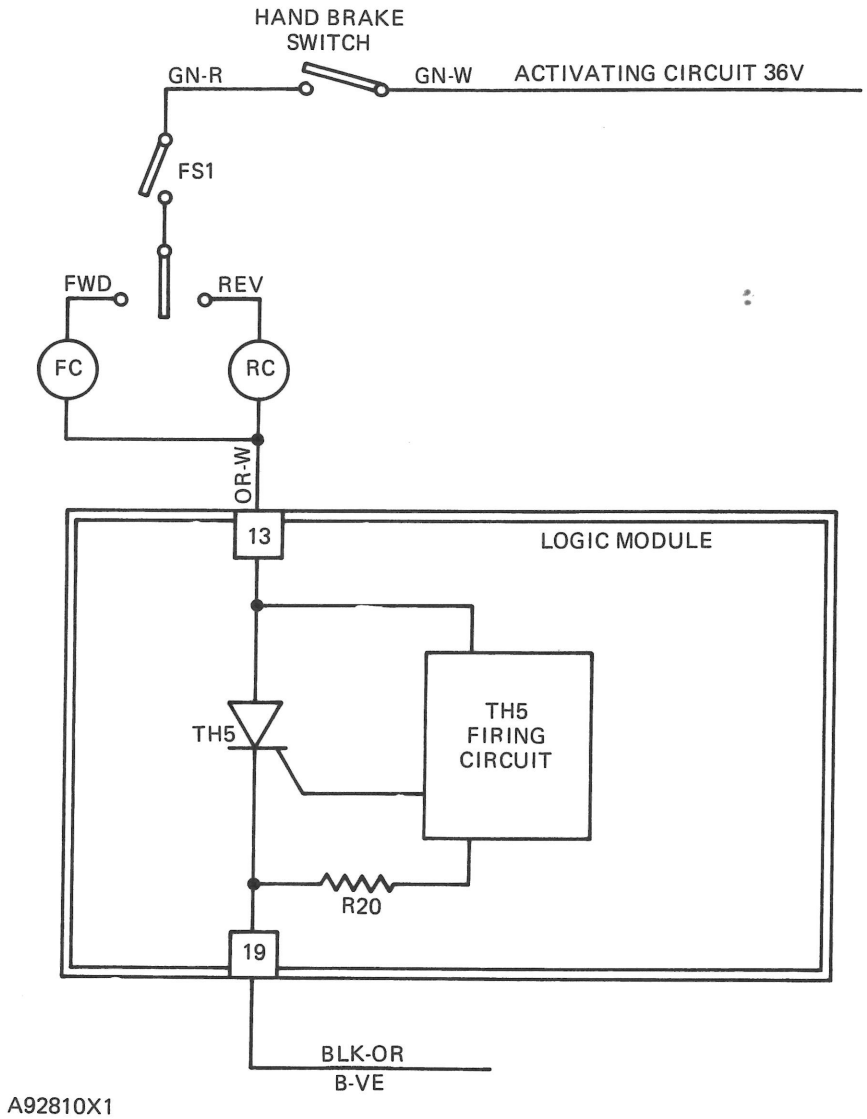
The current limit circuit has operation only with the pulsing current (TH1 operation time). The pulsing circuit sensing device uses the effect of the overswing voltage. When TH1 'turns off', the battery and cable inductance will cause a positive voltage transient at the anode of TH1. Because this effect is proportional (equal) to the current flow through the motor, it is used for its regulation. When the specific level is reached, the clamping switch decreases the charging current to capacitor C16. This action decreases the load to TH1 by application of a longer 'off time.'

When the clamping switch is closed, the pulsing sensing device will discharge itself to be free for a new operation cycle.

The maximum pulsing current has regulation by the setting of potentiometer VR3 on the printed circuit board of the Logic Unit. See topic Current Limit Adjustment in Testing and Adjusting.

The correct setting of current limit is:
for 36 and 48 volt trucks ..... 450 amps
for 72 and 80 volt trucks ..... 350 amps

FORWARD-REVERSE CONTACTOR CIRCUIT



FORWARD — REVERSE CONTACTOR CIRCUIT

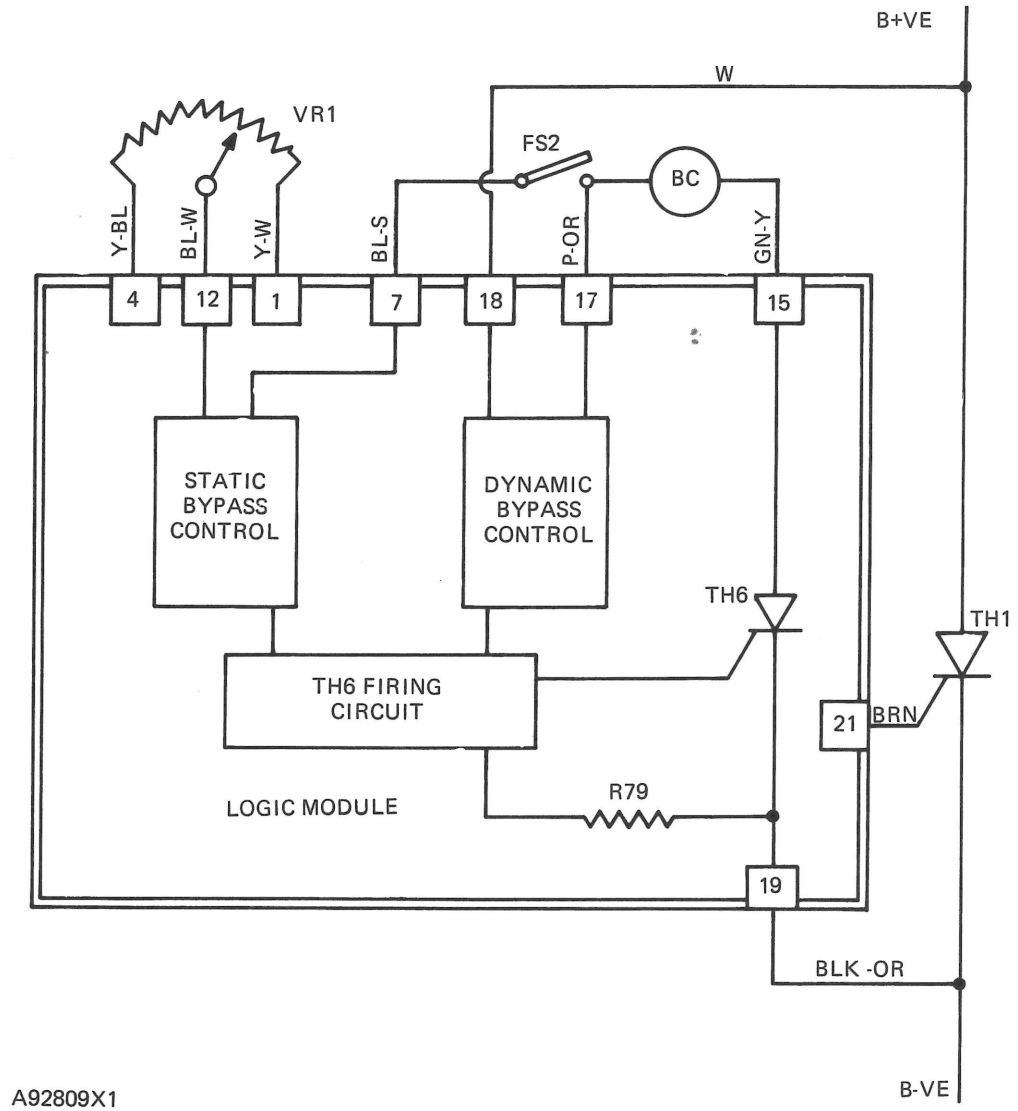
This circuit controls the direction in which the truck will move. It will close the forward or reverse contactor by firing TH5, if the logic module does not sense a 'fault' in the control circuits. The firing circuit takes the signal from TH5 anode and transfers it into a gate signal after a short time delay.

To complete the circuit the operator must engage the Battery Connector, turn on the Key Switch, release the Hand Brake to close the Hand Brake Switch, move the Direction Switch to Forward or Reverse and operate the accelerator to close FS1. Current will then flow through the circuit to pin 13 of the Logic Unit, through Thyristor 5 (TH5) to pin 19 and then to the Battery Negative Terminal (−ve). The current flow will cause the correct contactor to close.

The conditions which follow will cause the current flow in the circuit to stop.

1. The accelerator pedal is released (FS1 opens).
2. The Directional switch is moved to the NEUTRAL position.
3. The Hand Brake is moved to the ON position (Hand brake switch opens).
4. TH5 is turned off by the failure protection circuit.
5. The Key Switch is turned off.

BYPASS CONTROL CIRCUIT



BYPASS CONTROL CIRCUIT

When the bypass contactor is closed, full battery voltage is applied to the drive motor, and the truck will move at maximum speed. It is most important to have control of the bypass contactor to make sure of smooth and safe operation of the truck.

The circuit contains three main modules:

1. Static bypass control — This module senses the position of the foot pedal VR1 (voltage at pin 12 and if FS2 is activated).
2. Dynamic bypass control — It senses the pulsing frequency of TH1 and makes contact only if about 90% of the pulsing speed is reached.
3. TH6 firing circuit — This circuit needs a signal that the first two modules are acceptable. If they are o.k., a gate signal is sent to TH6. When TH6 is 'turned on', the bypass coil will be activated.

The bypass contactor will close after these conditions:

a. Activating circuit is closed.

b. Forward and reverse circuit is closed.

c. Foot pedal VR1 depressed beyond microswitch FS2.

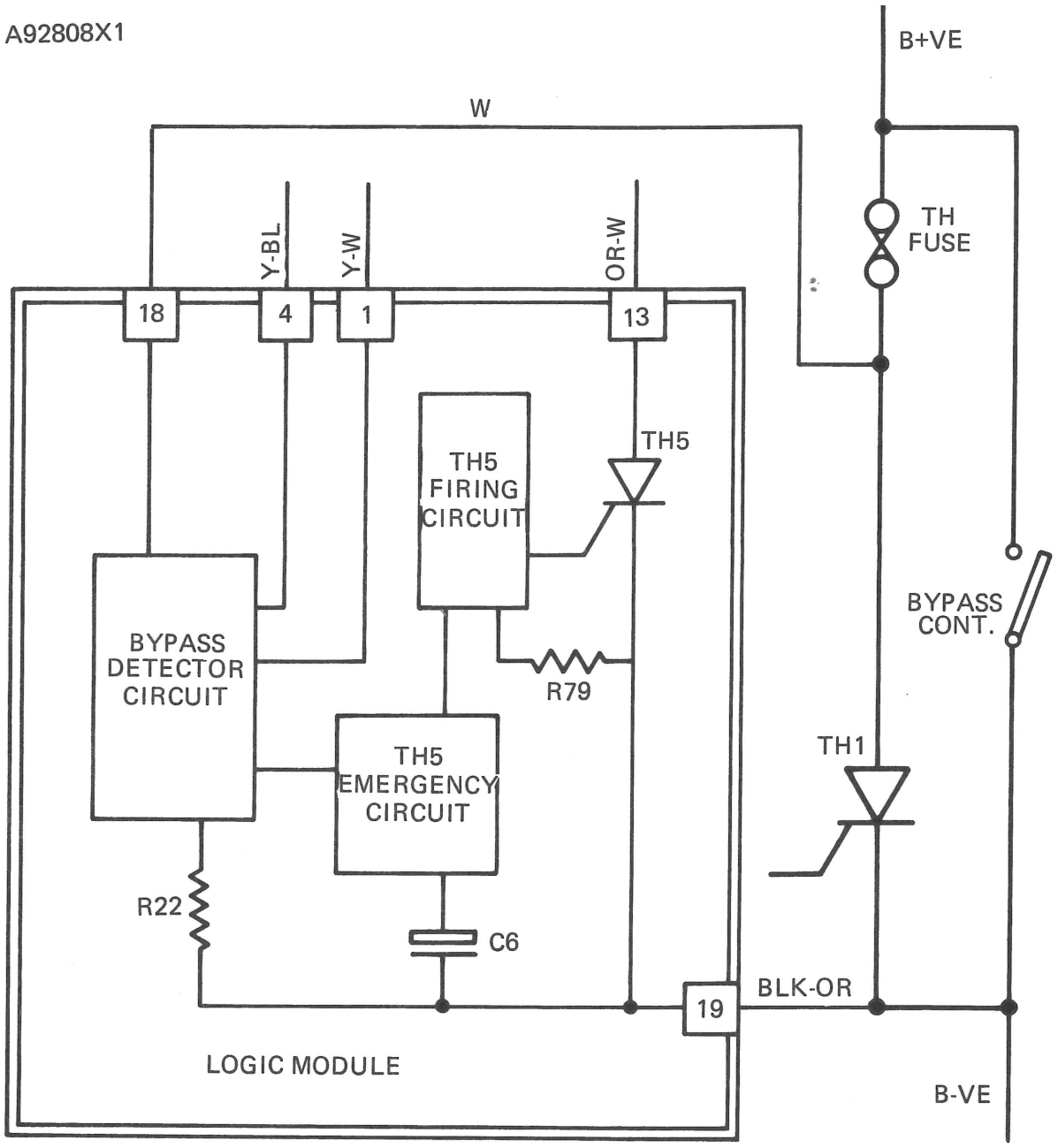
d. Thyristor TH1 is pulsed at the frequency that will cause it to be 'ON' 90% of the time.

The bypass contactor will open if: (a) or (b)

a. Foot switch (FS2) is opened.

b. The directional switch is moved to the NEUTRAL position.

BYPASS WELD-IN PROTECTION



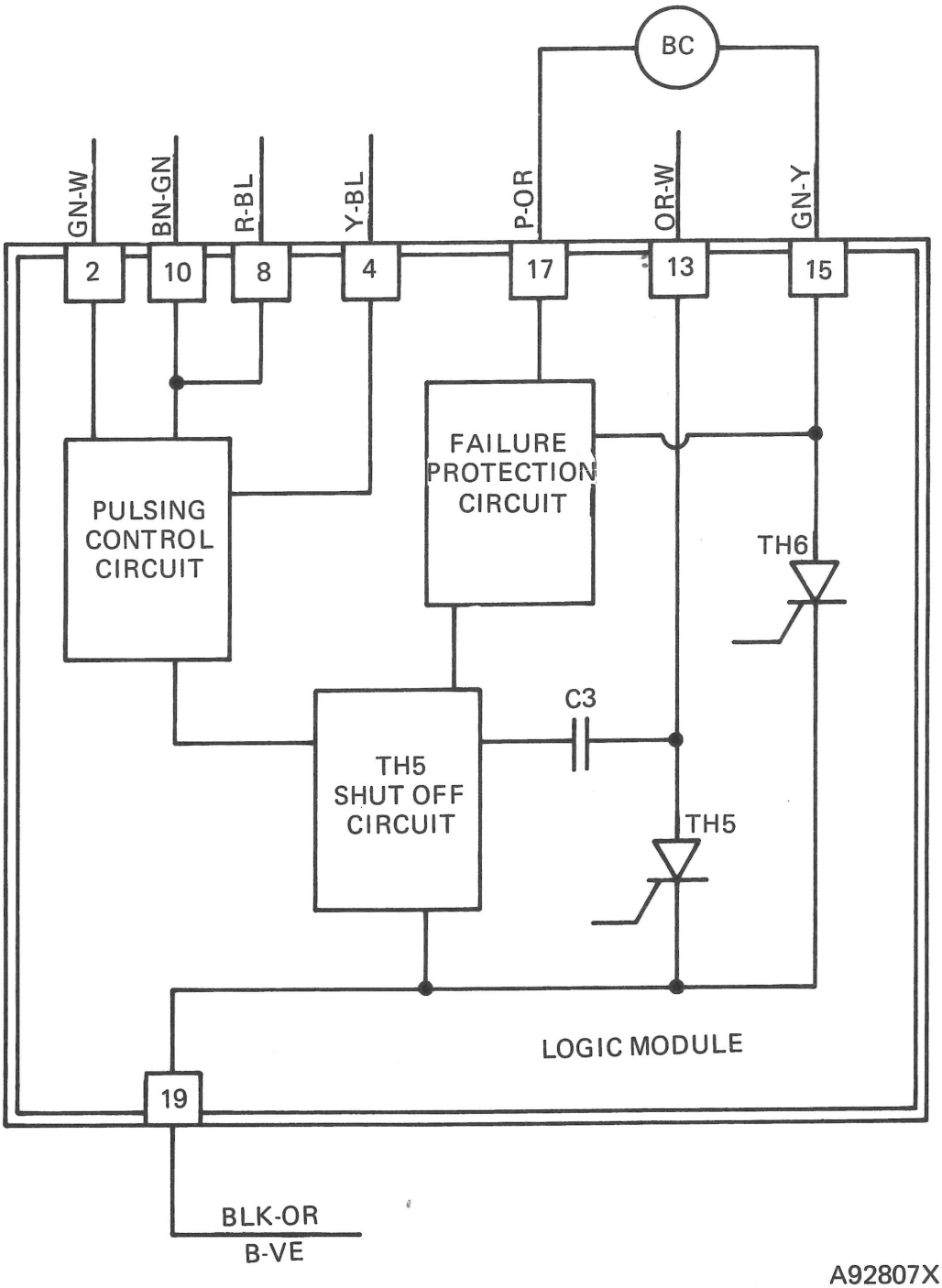
BYPASS WELD-IN PROTECTION

The direction contactor must never be permitted to close if the bypass contactor should be welded closed.

To prevent this from happening, a bypass detector circuit is constantly connected across TH1. A current supply from the 18 volt (pin 4) and 9 volt line (pin 1) causes a low voltage across TH1 with indication of good contactor condition. With this acceptable action, the control panel has normal operation.

But, if the bypass contactor stays welded closed, the current from the 18 volt and 9 volt supply lines is connected directly to battery negative (B—VE). The bypass detector will send no information to the TH5 emergency circuit, which will prevent the operation of TH5 firing circuit. When TH5 receives no gate firing signal, the direction contactors can no longer be engaged.

FAILURE PROTECTION CIRCUIT



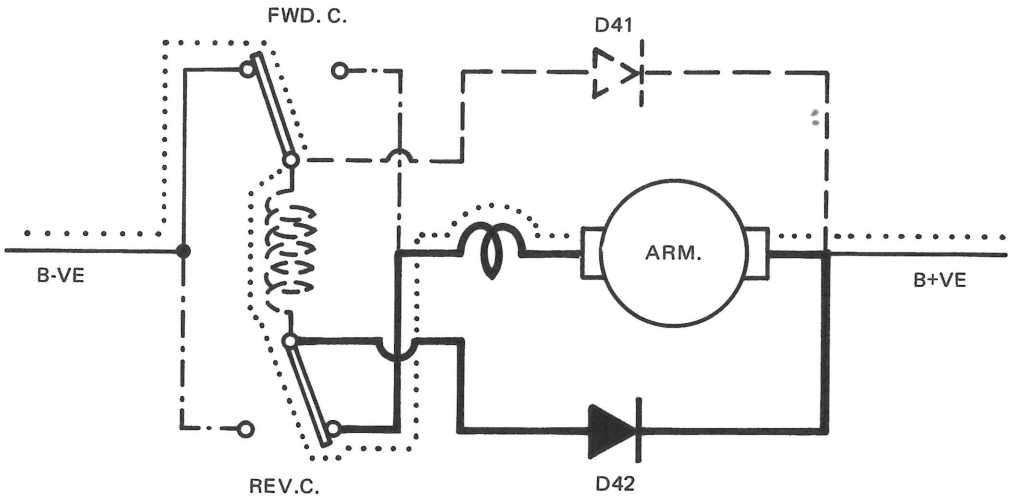
FAILURE PROTECTION CIRCUITS

The failure protection circuit checks the commutation circuit, or more exactly the 'on time' of TH1. This is done by the pulsing control circuit. If TH1 'on time' is more than its specific time (1.5 milliseconds), the pulsing control circuit will activate the TH5 Shut Off circuit and open the direction contactors by 'turning off' TH5.

Failure Protection Inhibition

When the bypass contactor comes in (closes), we need also the directional contactor closed because it is arranged in series. So, TH1 will not commutate. In this situation, the failure protection inhibition circuit prevents operation of the TH5 Shut Off Circuit.

PLUGGING CIRCUIT
(Outside Logic Module)



A89303-1X1

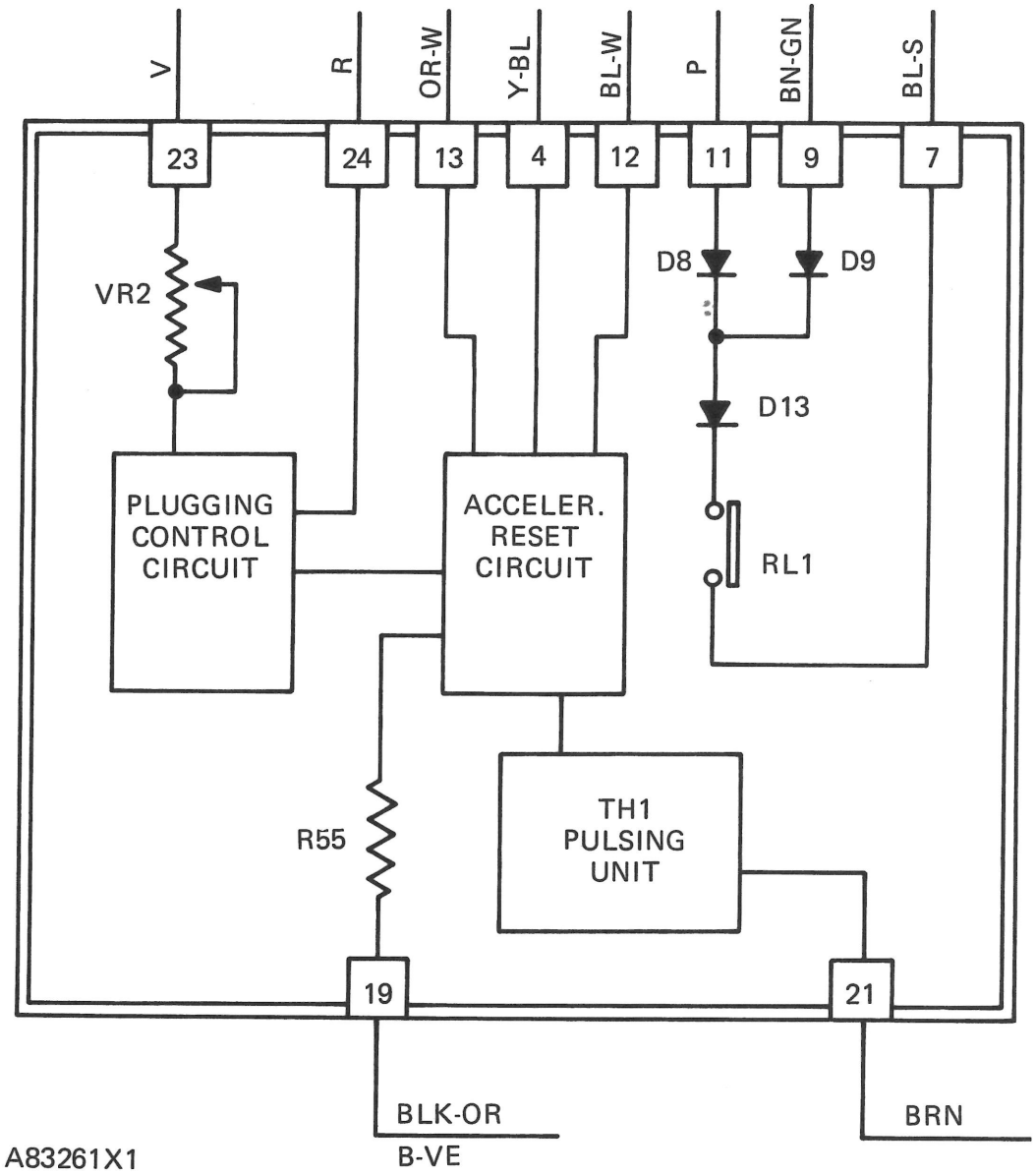
PLUGGING CIRCUIT (OUTSIDE LOGIC MODULE)

When the operator moves the directional lever from one direction to the other while the truck is in motion (has movement), the polarity of the drive motor field is reversed and the truck is "Plugged." The truck wheels turn the motor and cause it to become a generator. The armature generates (makes) a high current which circulates (flows) through one of the two power diodes, D41 or D42. Diode 42 is used with reverse contactor and D41 is used with forward contactor engagement. The diodes are connected across the armature and interpole in a short circuit. They form a heavy load and this causes the truck to slow down (brake).

The Logic Unit feels the change in polarity of the voltage across the armature and resets (discharges) the acceleration delay capacitor to cut off pulsing signals from the speed control circuit. The pulsing of the "ON" oscillation is under the complete control of the "Controlled Plugging" circuit and the foot control unit.

When the truck is moving at a high rate of speed, TH1 will be pulsed at a low rate to give the correct amount of braking. As the speed of the truck decreases, TH1 will be pulsed at a higher rate to keep the braking action constant. When the movement of the truck has stopped and acceleration pedal is still held down, the truck will accelerate normally in the opposite direction.

Inside Logic Module



PLUGGING CIRCUIT (INSIDE LOGIC UNIT MODULE)

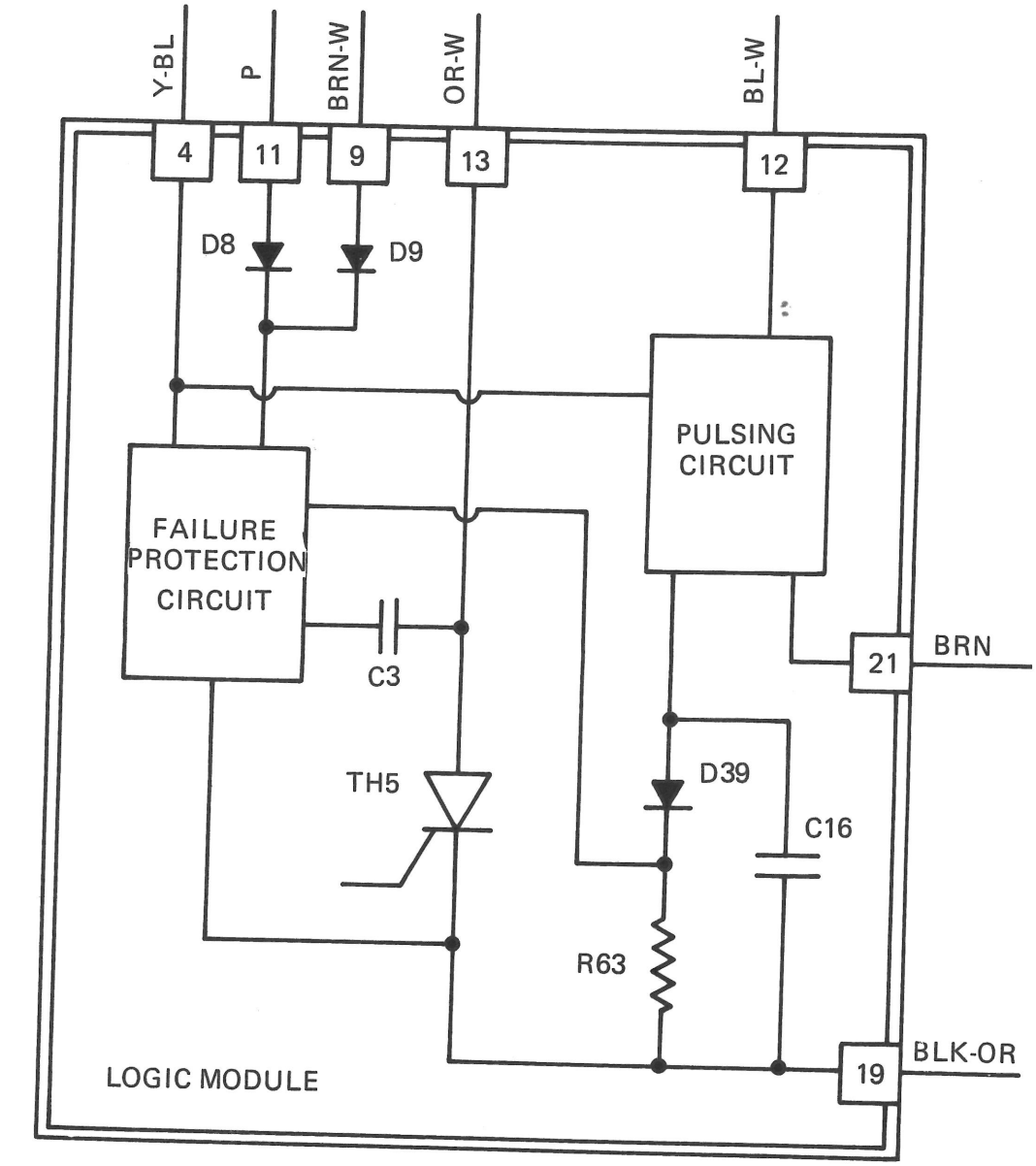
The degree of plugging is controlled by the position of the accelerator pedal and the adjustment of VR2 on the printed circuit board of the Logic Unit. An increase in the value of VR2 will increase the plugging current.

The Acceleration Reset Circuit makes sure that the TH1 pulsing Unit starts pulsing from zero and permits normal acceleration of the truck. Relay RL1 is in the circuit to provide a short time delay to make sure all TH6 triggering pulses are removed before voltage is sent again to the anode of TH6.

When the directional control lever is moved from the FORWARD to the REVERSE position and the truck is in motion, the truck operates in the sequence that follows.

1. The forward contactor opens and the reverse contactor closes. Polarity of the motor field is reversed.
2. This causes a reversal of the armature voltage which is felt by the Logic Unit. The Logic Unit reduces the pulse frequency.
3. As the truck moves, the motor operates as a generator because the motor field is excited by battery current.
4. As the armature slows down, TH1 is pulsed faster to keep a constant braking torque until the truck comes to a controlled stop.
5. The truck then accelerates (moves) normally in the reverse direction.

PROTECTION CIRCUIT



A92806X1

PROTECTION CIRCUIT

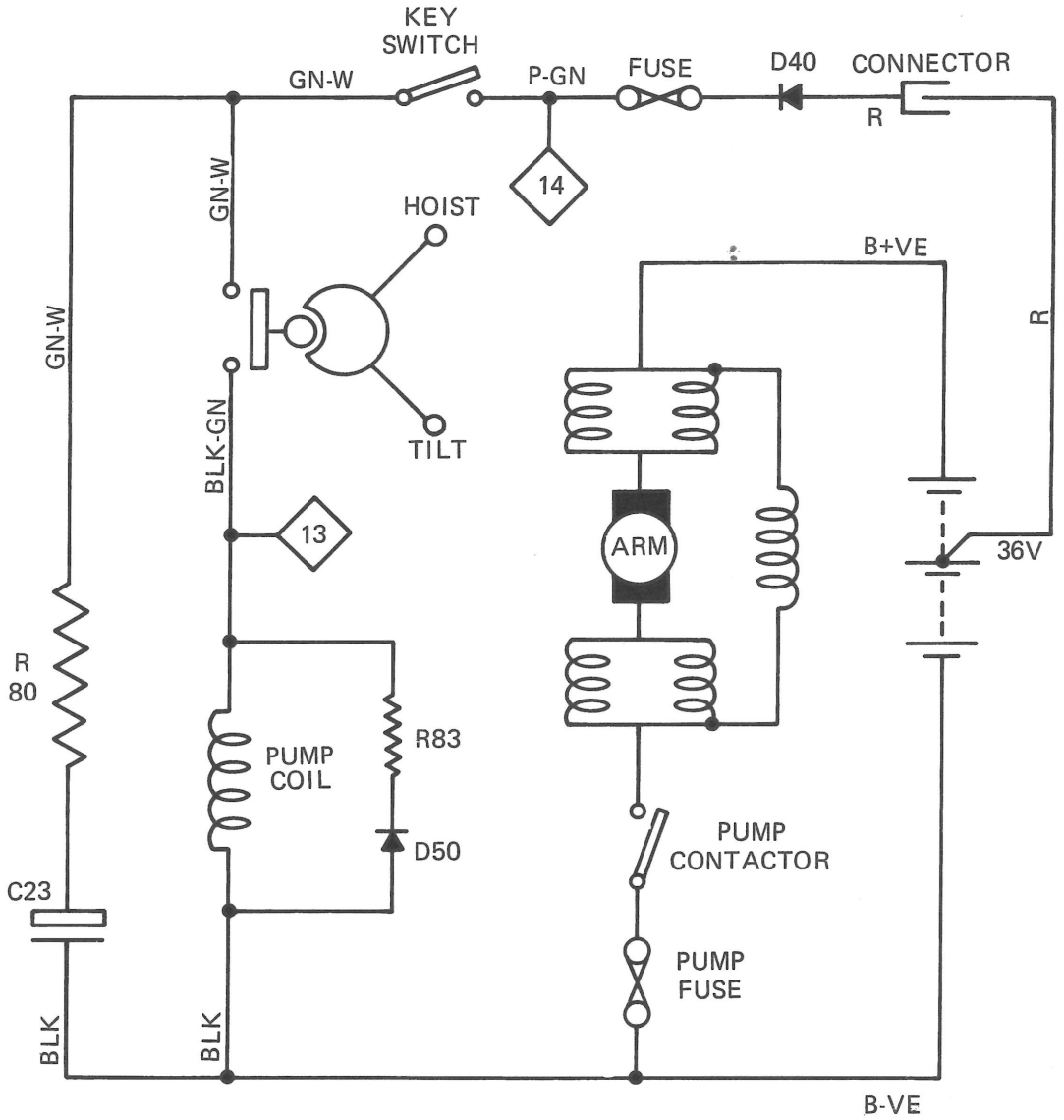
The protection circuit has operation on two circuits at the same time.

1. It opens the directional contactors by 'turning off' thyristor TH5.
2. It stops thyristor TH1 pulsing by causing a short circuit to capacitor C16 with the use of diode D39 and resistor R63.

Diode D39 is reverse biased during normal operating conditions.

PUMP CONTROL CIRCUITS

Earlier Models



PUMP CONTROL CIRCUIT (EARLIER MODELS)

The pump control circuit has control for operation of the hydraulic pump motor.

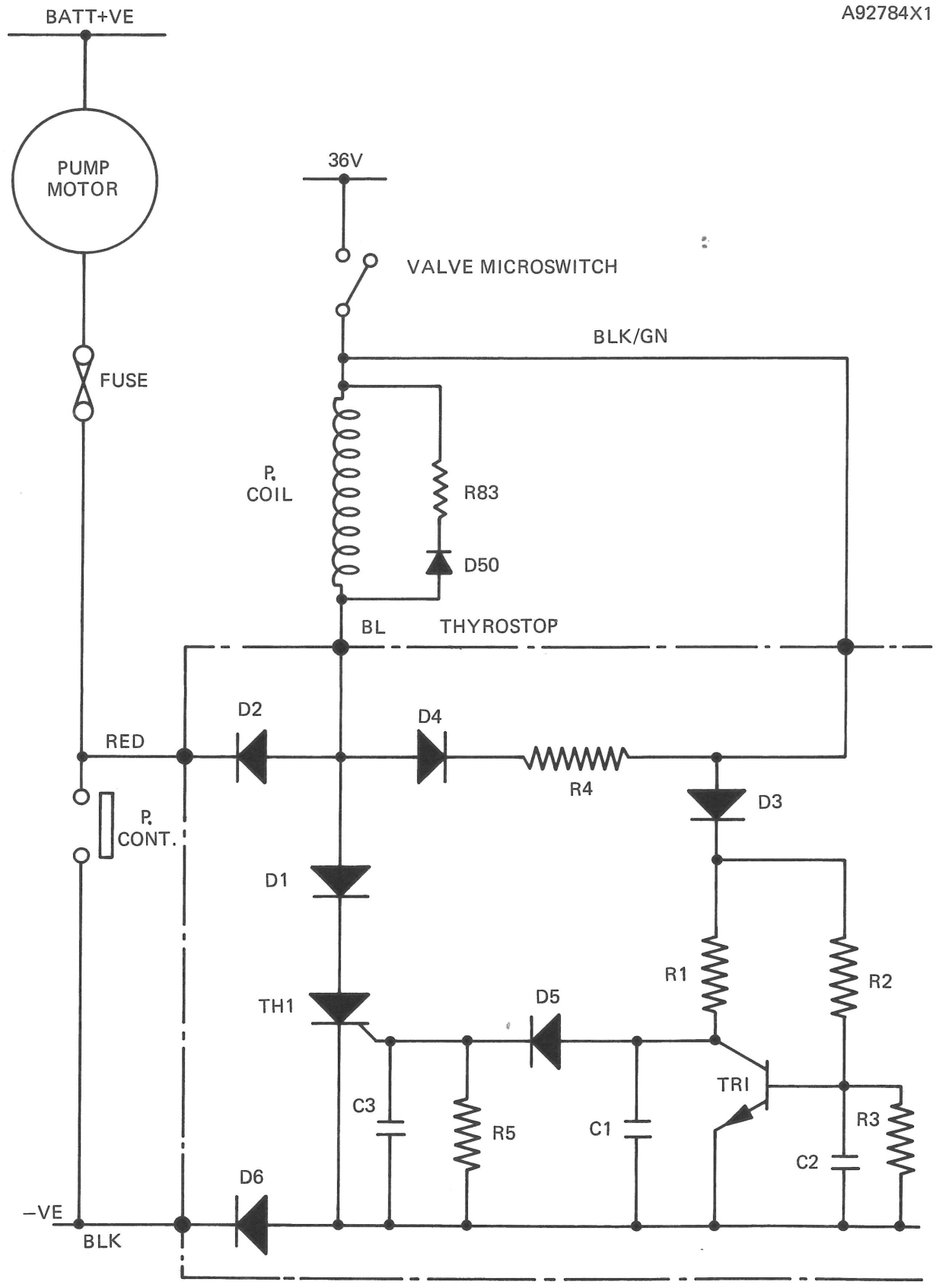
The pump control circuit has operation when the activating circuit is closed and the Hoist, Tilt or Attachment lever is activated.

When the control valve microswitch is activated, current flows through the Pump Coil and causes it to be energized. When the coil is energized, it makes a magnetic field and closes the Pump Contactor to let current flow through the pump motor. The pump motor rotation turns the hydraulic pump, which gives oil pressure for operation of mast and attachments.

Later Models

The pump control circuit for later trucks has an electronic module in the circuit to give a short delay in the time after the Pump Coil is activated and Pump Contactor closure. This electronic module is a Thyrostop. Its operation is explained in the topic that follows.

THYROSTOP MODULE



SCHEMATIC OF THYROSTOP CIRCUIT (LATER MODELS)

Operation

When the valve levers are released, the Thyrostop circuit draws no current.

When a valve lever is operated, current flows in the Thyrostop as follows:

Capacitor C1 charges by current from diode D3 and resistor R1.

Capacitor C2 charges by current from diode D3 and resistor R2 for 10 milliseconds.

Thyristor TH1 triggering potential is reached and starts to conduct. This gate signal delay prevents thyristor TH1 from conducting before the microswitch contacts have stopped bouncing which normally takes 6 milliseconds. This delay eliminates arcing at the microswitch contacts during closure. It also eliminates voltage transients (oscillations) across the contactor coil because of repeated interruptions of the coil supply voltage.

The coil current can only start to flow after TH1 has fired. Capacitor C2, charges up on a longer time constant but after approximately 25 milliseconds its voltage will be high enough to cause conduction of transistor TR1. R1 and R2 make sure TR1 collector voltage is at a specific low value when in conduction. Conduction of TR1 completely clamps the gate feed to TH1.

If the battery has less voltage (discharged), C2 will charge at a slower rate but the gate pulse to fire TH1 is terminated well before the contactor tips open. The pump contactor will close its contacts approximately 50 milliseconds after TH1 conducts and diverts (sends) the coil current away from TH1. As the combination voltage drop of D2 and pump coil is less than the voltage to cause D1 and TH1 to conduct in series, TH1 will turn off.

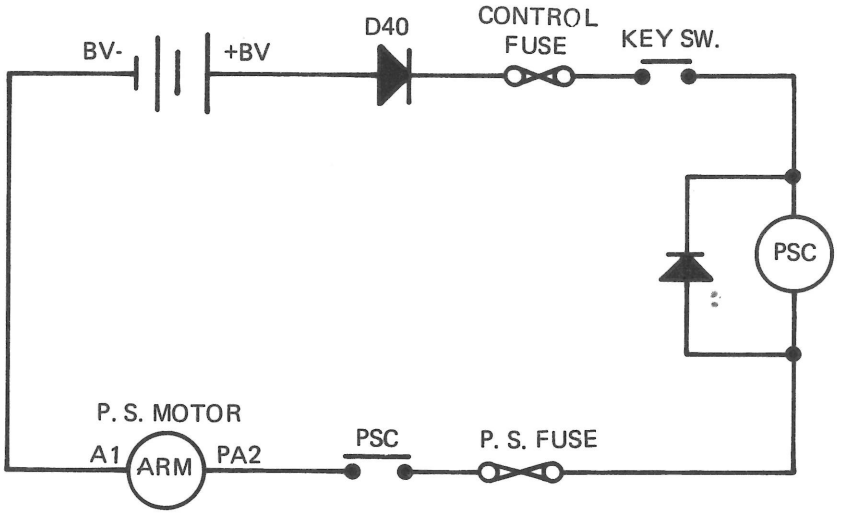
If the voltage of the 36 volt tap should now drop below the drop out voltage of the contactor, the pump contactor will open and break the coil circuit. The circuit has been designed to be sure that TR1 remains in conduction even if the battery voltage drops to 4 volts. The base emitter voltage will remain for a considerable period even if the 36 volt tap voltage should drop to zero because of the 400 millisecond discharge time constant of C2. This is enough time to be sure that TR1 stays in conduction no matter how far the battery voltage drops when the contactor tip closes.

Diode D6 is installed in the negative lead to make sure that TH1 is always commutated when the pump contactor tips are closed.

The Thyrostop module is installed in the hydraulic pump (lift) circuit for reasons as follows:

1. Protection for the pump contactors from burning (sizzling) condition when operated on a discharged battery.
2. Has operation on any battery between 36 and 80 volts if equipped with a 36 volt tap.
3. Prevents arcing at the control valve microswitch during make (when activated).
4. Reduces arcing at the control valve microswitch during break (when released).
5. It limits the contactor coil transient (oscillation) voltage to 50 volts maximum.
6. Prevents multiple operation of the pump contactor because of valve lever bounce.

POWER STEERING CIRCUIT



A92783X1

POWER STEERING CIRCUIT

NOTE: Power Steering is optional equipment for M20, M25 and MC30 lift trucks.

This circuit is used to operate the pump motor to operate the power steering pump. The circuit has operation when the battery is connected and the key switch is turned on to activate the power steering coil (PSC). When the coil is activated, it creates a magnetic field and closes the power steering contactor (PSC). Current now goes through the closed contacts for operation of the power steering motor.

BETTER BATTERY PERFORMANCE

Maximum life and performance for lift truck batteries is dependent on the truck operator, battery charging, maintenance and service.

The truck operator must not start his shift with a battery that has been taken off a charge too soon. A battery should never be disconnected from a charger until the charge cycle has been completed. The batteries that have been fully charged should have a tag installed for identification. Repeated undercharging must be prevented because it can damage the battery.

Undercharging can also be the cause of over discharging and low-battery operation, where duty cycles are heavy. To prevent this, the truck can be equipped with a warning device, such as a discharge indicator.

Low-battery operation must be prevented. It can not only damage the battery but can cause damage to motor contactors on the SCR Control Panel. The truck and battery cables and connectors must be tight to prevent overheating and pitting of the contactors.

The truck operator must return the truck to the battery charging area if there is an indication of low-battery operation. These symptoms (indications) could be a noticeable slowing down of lift and travel speeds or a low reading on a Battery Discharge Indicator, or a warning light from a Lift Interrupter.

A "cycle charge" will completely re-charge the battery. The typical cycle charge for a fully discharged battery usually is an eight-hour charge. The battery must be recharged before it has been over discharged. An approximate limit is an 80% discharge or 80% of the rated capacity of the battery. The work shift of the truck can be planned so the battery will not be discharged more than 80%.

An "equalizing charge" is a cycle charge with modification, given usually at an interval to bring all cells up to a state of equal charge. An equalizing charge usually adds three or four more hours to the cycle charge, at a low finish rate. It is usually given when the specific gravity (SG) of electrolyte has a variation of more than 15 points (.015) from cell to cell, after a regular cycle charge.

A "freshening charge" is given to bring a new battery up to full charge. It is also given to a battery that has been in storage for some time. This is a charge given at a low finish rate for about three hours until the specific gravity has no increase. (See topic Battery Tests in Testing and Adjusting).

"Washing down" batteries at different time periods will make less the possibility of "grounds" caused by electrolyte spills and corrosion. If done often enough, just washing with water alone will eliminate the need for using baking soda. If not, a solution of baking soda and water must be used to wash battery at different time periods.

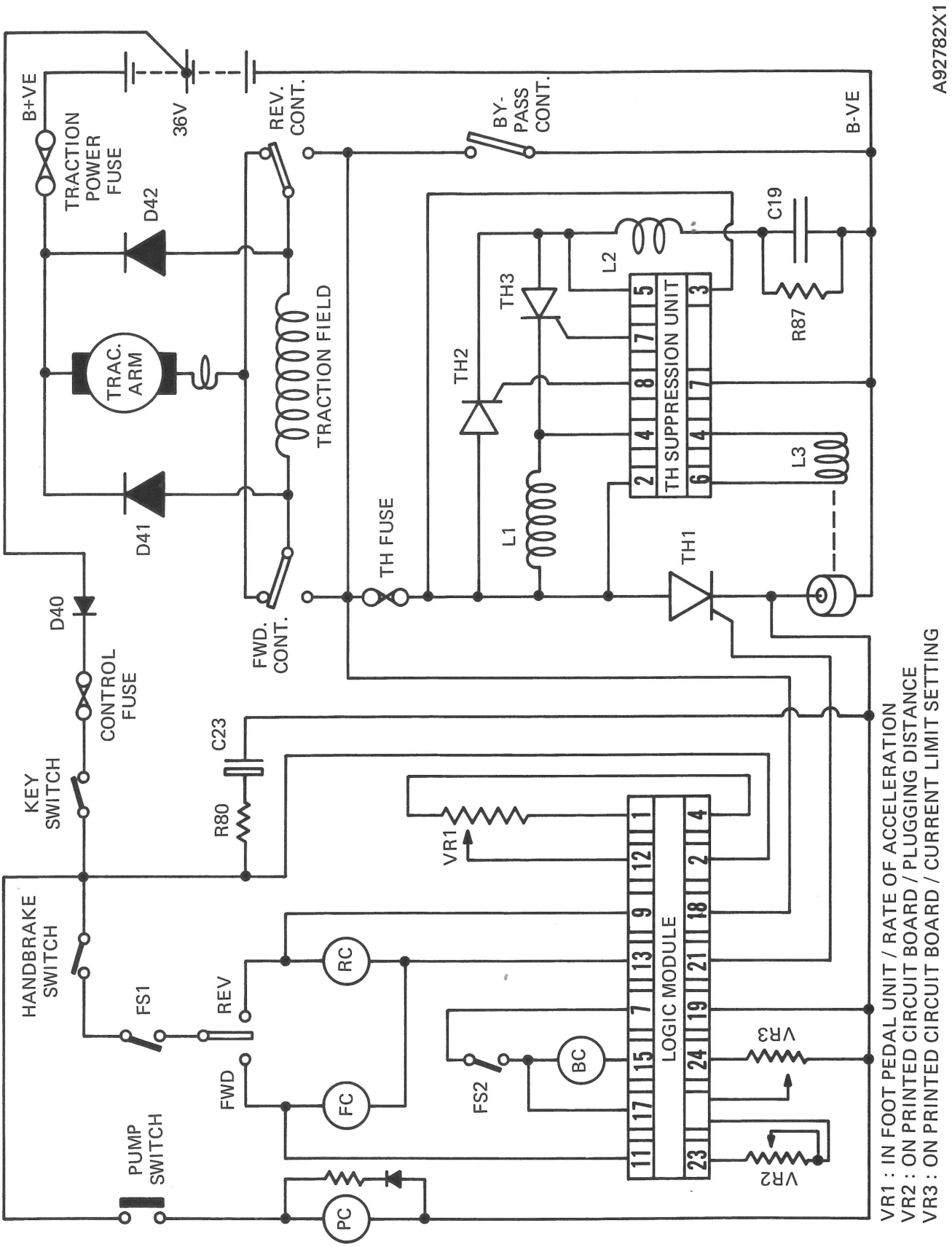
NOTE: Ventilation caps must be kept in place during the "washing" operation.

When a battery charger operates correctly and brings a good battery up to full charge, the current readings will level to the "finish rate," the charging voltage will stabilize (be equal), the specific gravity will stop rising (no more increase), and normal gassing can be seen.

⚠ WARNING

Hydrogen and oxygen gases are given off as battery plates get near a full charge condition. These gases are highly explosive and caution must be taken to make sure no arc, spark, or flame comes into contact with the generated gases. The possibility of explosion is always present with exposure of the battery to sparks or flame, but is especially hazardous at the end of the charging period.

SIMPLIFIED SCHEMATIC FOR TROUBLESHOOTING PURPOSES



TROUBLESHOOTING

On the pages that follow is a list of possible problems. To make a repair to a problem, make reference to the possible cause and checks, tests, results and procedures.

NOTE: Before any of the tests or checks that follow are made, be sure the battery is fully charged. See topic Battery Tests in Testing and Adjusting.

Always make visual checks first. Check for loose wires, insulation off of wires, linkage to accelerator switch (for correct adjustment), and signs of components being too hot. Contactors must operate freely. Be sure wires do not have an effect (cause interference) with their operation.

⚠ WARNING

Before any contact is made with electrical components, disconnect battery and discharge C19 Capacitor. When testing or adjusting operation of the truck, lift the drive wheels off the floor. Put wood blocks under the frame. Keep away from wheels that are in rotation.

CAUTION

Make resistance and continuity checks only after battery is disconnected and C19 capacitor is discharged. Damage can be caused to the testing equipment.

CAUTION

Do not use steam to clean the controls. Use pressure from an air hose with a maximum pressure of 30 psi (205 kPa) to clean the control panel when necessary. Make sure the air pressure supply is equipped with a water filter.

Troubleshooting Hints

During normal operation, sounds are made by control panel components. These sounds can be used in troubleshooting. With the directional selector in forward or reverse, the directional contactors will make a noise when closing once the accelerator pedal is depressed far enough to activate FS 1. When the accelerator pedal is depressed far enough to activate FS 2, the by-pass contactor will close and make a sound. The hydraulic pump contactor will also make a sound when this circuit is activated.

Also the Power Unit will make a series of short sounds, called pulsing, which should become more rapid as the accelerator pedal is depressed.

⚠ WARNING

Drive wheels should be off the floor during testing. Do not touch any wiring terminals or components on the control panel unless the battery is disconnected and the C19 capacitor is discharged. Otherwise always use an object that has insulation.

Problems

1. Lift truck does not move. Directional contactors do not close.
2. Lift truck does not move. Directional contactors close, unit does not pulse.
3. Lift truck does not move. Directional contactors close, unit pulses slowly.
4. Lift truck moves slightly and then stops. Directional contactors are closing and then opening.
5. Lift truck moves and accelerates, but loses power at low speed. Directional contactors are closing.
6. Lift truck moves and accelerates, but will not reach full speed. By-pass contactor is not closing.
7. Lift truck operates normally but stops when the by-pass contactor is released.
8. Lift truck operates normally but stops or burns out the high speed thyristor fuse when plugging.
9. Lift truck operates normally except under heavy load.
10. Lift truck accelerates slowly in one or both directions. Plugging not effective in one or both directions.
11. Current limit in SCR range too high, and can not be adjusted.
12. Operation normal, but poor performance on a ramp, towing or chiseling.
13. Pump motor fails to start.
14. Pump contactor does not close.

PROBLEM 1

Lift truck does not move. Main direction contactors do no close.

POSSIBLE CAUSE

Control fuse burnt out, shorted or open wires between battery and hand brake switch; bypass contactor tips welded together; shorted or open wires between foot switch and contactor coil; open circuit in connector coil. Logic unit does not operate correctly.

CHECKS

⚠ WARNING: Wheels should be off ground during test.

Check control fuse.

If good . . . . . If open . . . . .

Check wire harness for short circuit and replace fuse.

Turn on key switch, and check voltage at Y-BL wire at Pin 4 of the Logic Unit.

If there is voltage (18V) . . . . . If there is no voltage . . . . . .

Check voltage at 36V tap at battery connector, hand brake switch, D40, control fuse, key switch and GN/W wire of R80. It should be 36V at all points. If supply to R80 is 36V, then R80 is burned out, replace.

Push down accelerator pedal and check voltage at selected direction contactor coil.

If there is voltage (36V) . . . . . If there is no voltage . . . . . .

Check normally open foot switch FS1, direction switch and wiring between the above points and on the contactor coil for shorts, grounds, broken or loose wires.

Check to see if bypass contactor is welded.

If not welded . . . . . If welded . . . . . .

Check the bypass contactor for welded contact tips or wiring broken. If voltage is .5 to 1V, it is possible the TH5 (SCR5) has fired and contactor did not pull in because of a mechanical fault such as stiff spring or shorted turns.

Check voltage at Pin 13 on Logic Unit.

If there is 36V . . . . . If there is no voltage . . . . . .

Check wiring, and, for an open circuited contactor coil or defective contact in direction switch.

Check continuity between Pin 19 on Logic Unit and cathode of Thyristor 1 (SCR 1).

If good . . . . . If broken . . . . . .

Repair or replace as necessary.

Replace Logic Unit. Fault in TH5 (SCR5) circuit.

PROBLEM 2

Lift truck does not move. Directional contactors close. Unit does not pulse.

POSSIBLE CAUSE

Thyristor high speed fuse burnt out due to D41 and/or short circuit or short circuit in motor or associated cables. Open circuit in battery positive line or in motor. Thyristor No. 1 or Logic Unit do not operate correctly. Directional contactor tip corrosion or fault. Foot controller fault.

CHECKS

⚠ WARNING: Drive wheels should be off ground during tests with forward contactor closed, check voltage on No. 1 Thyristor heat sink (anode).

If there is less than battery voltage .....

If battery voltage .....

Check for battery voltage at Pin 18 of Logic Unit.

If there is voltage .....

If there is no voltage .....

Check white wire between Pin 18 and Thyristor fuse.

Check voltage at supply side of Thyristor fuse.

If battery volts .....

If less than battery volts .....

Check forward contactor N/O contact, reverse contactor N/C contact, motor and cable and positive contact of battery connector for open circuit voltage drops from corrosion.

Check for open circuit between pin (21) and gate No. 1 Thyristor. Also check for short circuit between gate and cathode on No. 1 Thyristor.

Check for correct voltage from potentiometer VR1 Pin 17 at Logic Module. Voltage must range between 18 and 9 V as pedal is pressed.

If voltage is correct .....

If voltage to Pin 12 not correct (18 V constant).....

Repair potentiometer or leads.

Check diodes D41 and D42 by removing the cable clamps and checking their resistance with an ohmmeter.

If diode shorted .....

If diode is good .....

Replace diode and high speed Thyristor fuse.

Check for a short circuit in the motor or its cables. Replace the high speed Thyristor fuse.

Supply gate lead signal of 18V (R80) (R-Y) to gate of TH1.

If unit pulses .....

If no pulses .....

Change Logic Module.

Replace TH1 and retest.

NOTE: If intermittent failure occurs, it could be partially damaged Diodes D41, D42, or TH1 high speed fuse which may not operate as temperature increases.

PROBLEM 3

Lift truck does not move. Directional contactors close, unit pulses slowly.

POSSIBLE CAUSE

Speed control potentiometer or Logic Unit do not operate correctly.

CHECKS

⚠ WARNING: Drive wheels should be off ground during test.

Close Key Switch, Handbrake Switch and Direction Switch. Check for 36V on 36V tap. Battery could be faulty.

Check the voltage at Pin 4 of Logic Unit. It should be 18V.

If there is voltage..... If there is low voltage.....

Check the voltage at Pin 1 of Logic Unit. There should be approx. 9V.

If there is voltage ..... If there is low voltage.....

Check voltage at Pin 2 of Logic Unit.

If 36 volts ..... If 0 volts .....

Replace Logic Unit.

Check speed control potentiometer by checking voltage at Pin 12 of Logic Unit and pushing down speed control pedal. Voltage must go from 18V to 9V.

If correct voltage variation ..... No voltage variation .....

Check continuity from Pin 2 to the key switch.

Possible cause is diode D41 or D42, or both and partially shorted causing high amps — Unit senses high flow and current limit cuts back pulse rate. Replace defective diode.

If symptom still same .....

Check continuity from Pin 1 of Logic Unit and speed control potentiometer Pin 1.

If there is continuity ..... If there is an open .....

Change the speed control potentiometer.

Install new Logic Unit.

Repair open circuit.

PROBLEM 4

Lift truck moves a small amount and then stops. Directional contactors close and then open.

POSSIBLE CAUSE

Thyristor No. 1, No. 2 or No. 3 shorted; Logic Unit or Thyristor suppression module has a defect.

CHECKS

⚠ WARNING: Drive wheels should be off the ground during tests.

Connect shorting link between anode of D39 on Logic Unit and negative. With all switches closed, depress accelerator.

If truck does not move. If problem remains the same.

Install new No. 1. Thyristor.

CATHODE MUST BE DISCONNECTED FOR THESE CHECKS.

Check for continuity from the Thyristor Suppression Unit Pin 8 and the gate of TH2. With leads disconnected check resistance between Pins 4 and 8 of the Thyristor Suppression Unit with Pin 4 positive. Resistance must be approximately 1000 ohms (Forward voltage drop). Also check resistance between Pin 5 and Pin 8 of Thyristor Suppression Unit with TH2 gate lead disconnected from Pin 8. Resistance must be 220 ohms.

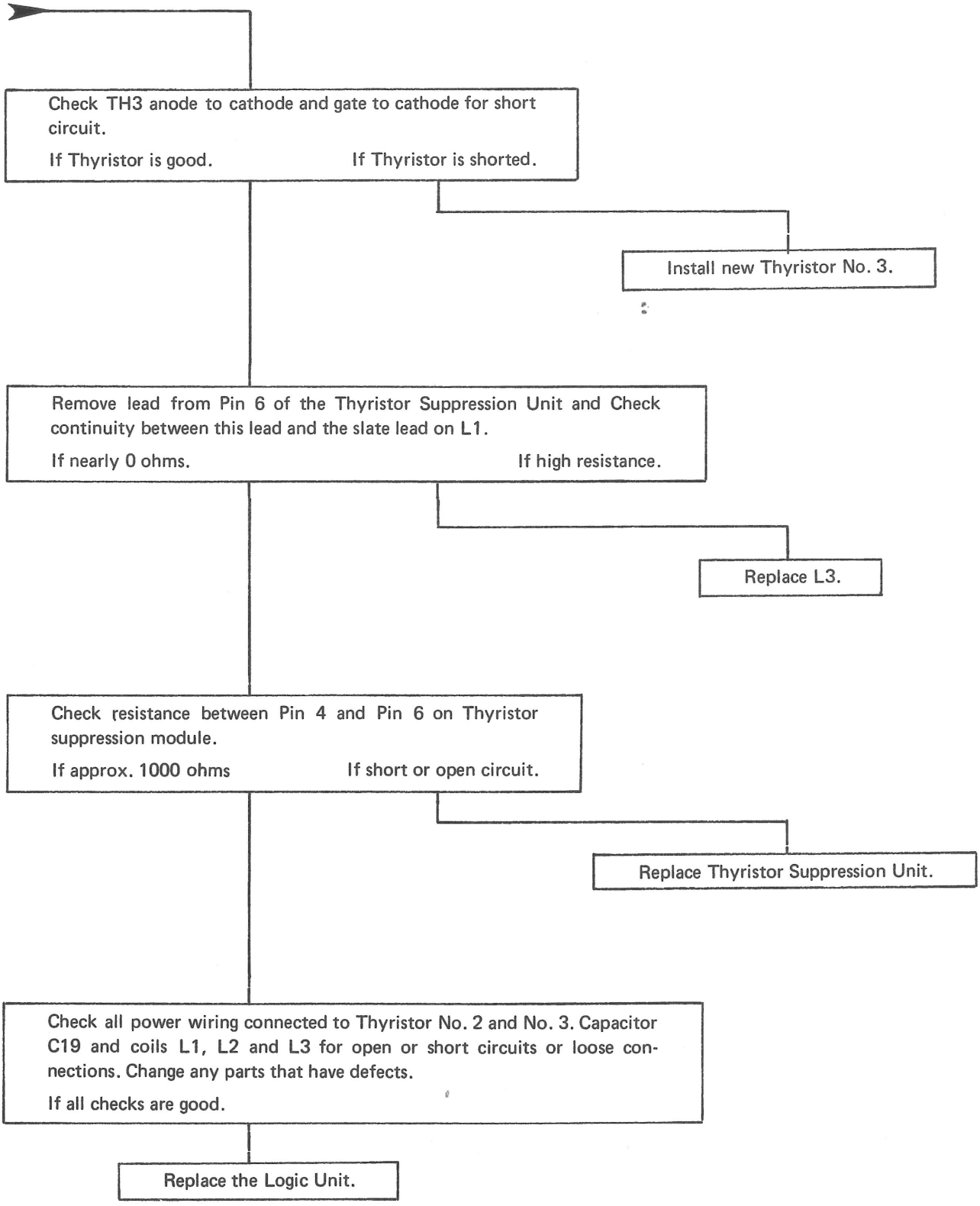
If checks are correct. If incorrect.

Replace Thyristor Suppression Unit.

Check TH2 anode to cathode and gate to cathode for short circuit.

If Thyristor is good. If Thyristor is shorted.

Install a new Thyristor No. 2.


Check TH3 anode to cathode and gate to cathode for short circuit.
If Thyristor is good.
If Thyristor is shorted.
Install new Thyristor No. 3.
Remove lead from Pin 6 of the Thyristor Suppression Unit and Check continuity between this lead and the slate lead on L1.
If nearly 0 ohms.
If high resistance.
Replace L3.
Check resistance between Pin 4 and Pin 6 on Thyristor suppression module.
If approx. 1000 ohms
If short or open circuit.
Replace Thyristor Suppression Unit.
Check all power wiring connected to Thyristor No. 2 and No. 3. Capacitor C19 and coils L1, L2 and L3 for open or short circuits or loose connections. Change any parts that have defects.
If all checks are good.
Replace the Logic Unit.

PROBLEM 5

Lift truck moves and accelerates but cuts out at low speed.

POSSIBLE CAUSE

Bad battery cells, excessive discharge, bad fuse, thyristor No. 2 or No. 3 breaking down under load, partial short circuit on C19, loose terminals at C19 or Logic Unit does not operate correctly.

CHECKS

⚠ WARNING: Drive wheels should be off the floor during testing.

Since the unit operates correctly at low power it is not possible to locate a faulty Thyristor by means of a multimeter; the Thyristor can only be verified by substitution.

If Thyristors are good .....

If Thyristors are faulty .....

Check battery for bad cell or too much discharge which can cause contactor dropout. Check for fuse that opens only when heated.

Check for reverse logic contact on one or both of direction contactors—weak springs, and or low voltage that opens up logic circuit.

Check the cam adjustment for FS1, engages with too little contact. Slight external bump can cause FS1 to open.

Check C19 for a partial short circuit. Check to see if all terminals are tight.

If good ..... If bad .....

Replace appropriate Thyristor.

Check all power wiring connected to Thyristor No. 2 and 3, Capacitor C19, and coils L2 and L3 for short circuits or loose connections.

If good ..... If bad .....

Replace capacitor or tighten connections.

Replace Logic Unit.

Remedy as required.

PROBLEM 6

Lift truck moves and accelerates, but will not reach full speed. Bypass contactor is not closing.

POSSIBLE CAUSE

Foot control switch; Logic Unit; not operating correctly. Current Limit setting, Direction coil or wiring.

CHECKS

⚠ WARNING: Drive wheels should be off the floor during testing.

Close Key Switch, Handbrake Switch and Direction Switch.

Press down foot control switch fully and check the voltage at the bypass contactor. The voltage must be 36V.

If there is no voltage . . . . . .

If there is voltage . . . . . .

Check continuity between Pin 7 of Logic Unit and Pin 11 of Foot Control Unit and from Pin 12 on Foot Control Unit to the Bypass contactor coil. Check continuity between Bypass contactor coil and Pin 15 of Logic Unit. Check direction contactor coils for correct resistance (38 to 45 ohms).

Repair any opens.

Check continuity between Pins 11 and 12 of foot control unit with pedal completely pushed down.

If continuity

If open circuit

With direction control activated; check for 36V at Pin 9 and at Pin 11 of Logic unit. If not 36V repair wire to coil.

If 36V. . . . . .

Replace Logic Unit

Adjust or replace foot control unit.

Check voltage at the foot control potentiometer wiper (Pin 12).

If above 9V. . . . . .

If 9V or below . . . . .

Check for correct setting of current limit, if o.k. . . . . .

Change Logic Unit.

Change or adjust foot control unit.

PROBLEM 7

Lift truck operates normally but stops when the bypass contactor is released.

POSSIBLE CAUSE

Battery is not fully charged; the Logic Unit not operating properly.

CHECKS

⚠ WARNING: Drive wheels should be off the floor during testing.

Check state of charge of battery. If the battery is in good condition change the Logic Unit.

PROBLEM 8

Lift truck operates normally but stops or burns out the high speed Thyristor fuse on plugging.

POSSIBLE CAUSE

The D41 and/or D42 diodes are open. Malfunction in the Logic Unit.

CHECKS

⚠ WARNING: Drive wheels should be off the floor during testing. Close Key Switch and Handbrake Switch.

Check voltage at Pin 24. If not battery voltage check for continuity between Pin 24 of Logic Unit and the heat sink of D41 and D42. Check the continuity of the violet wire between the reverse contactor and Pin 23 of the Logic Unit. Check D41 and D42.

If no defects are present . . . . . If defects are present . . . . . .

Replace Logic Unit.

Repair or replace any parts with defects.

PROBLEM 9

Truck operates normally except under a heavy load.

POSSIBLE CAUSES

Logic Unit does not operate correctly. Main thyristors break down under load, current limit set wrong.

CHECKS

⚠ WARNING: Drive wheels must be off the floor during tests.

Check current limit see: the CURRENT LIMIT CHECK section of TESTING AND ADJUSTING.

If current limit is correct . . . . . If current limit is not correct . . . . . .

Do the Current Limit Adjustment.

Check L1, L2, and L3 for open circuits.

No open circuits present Open circuits present

Repair or replace parts with defects.

Check capacitor C19 for defects.

C19 does not have a defect C19 has a defect

Replace Logic Unit

Replace C19

PROBLEM 10

Lift truck accelerates slowly in one or both directions. Plugging not effective in one or both directions.

POSSIBLE CAUSE

Flyback diodes D41 or D42 connected wrong.

CHECKS

Diode D41 or D42 for connection to wrong terminal, S1 or S2 connected to A2. (This causes no flyback current for the side connected wrong; result, poor acceleration. In one direction plugging will be O.K., but in other direction plugging has no effect).

PROBLEM 11

Current Limit in SCR range too high, and can not be adjusted.

POSSIBLE CAUSE

VR3 is defective.

CHECKS

VR3 adjustment too high and will not adjust, is defective.

If O.K. .....

Check for open circuit or any wire touching the frame of truck.

PROBLEM 12

Operation normal, but poor performance on a ramp, towing or chiselling.

POSSIBLE CAUSE

Current limit setting, defective motor, flyback diode.

CHECKS

⚠ WARNING: Drive wheels should be off the floor during testing.

Check motor amp current limit setting with ammeter. Must be 450 amps (36/48V) and 350 amps (72/80V).

Make adjustment to RV3.

If operation not acceptable .....

Flyback diodes, D41 or D42 may have a defect.

If O.K. .....

Motor may have a defect.

Pump Circuit

O/C = Open Circuit

PROBLEM NO. 13

Pump motor fails to start.

POSSIBLE CAUSE

Pump fuse blown. Power Cables O/C.
Pump contactor not closing.

CHECKS

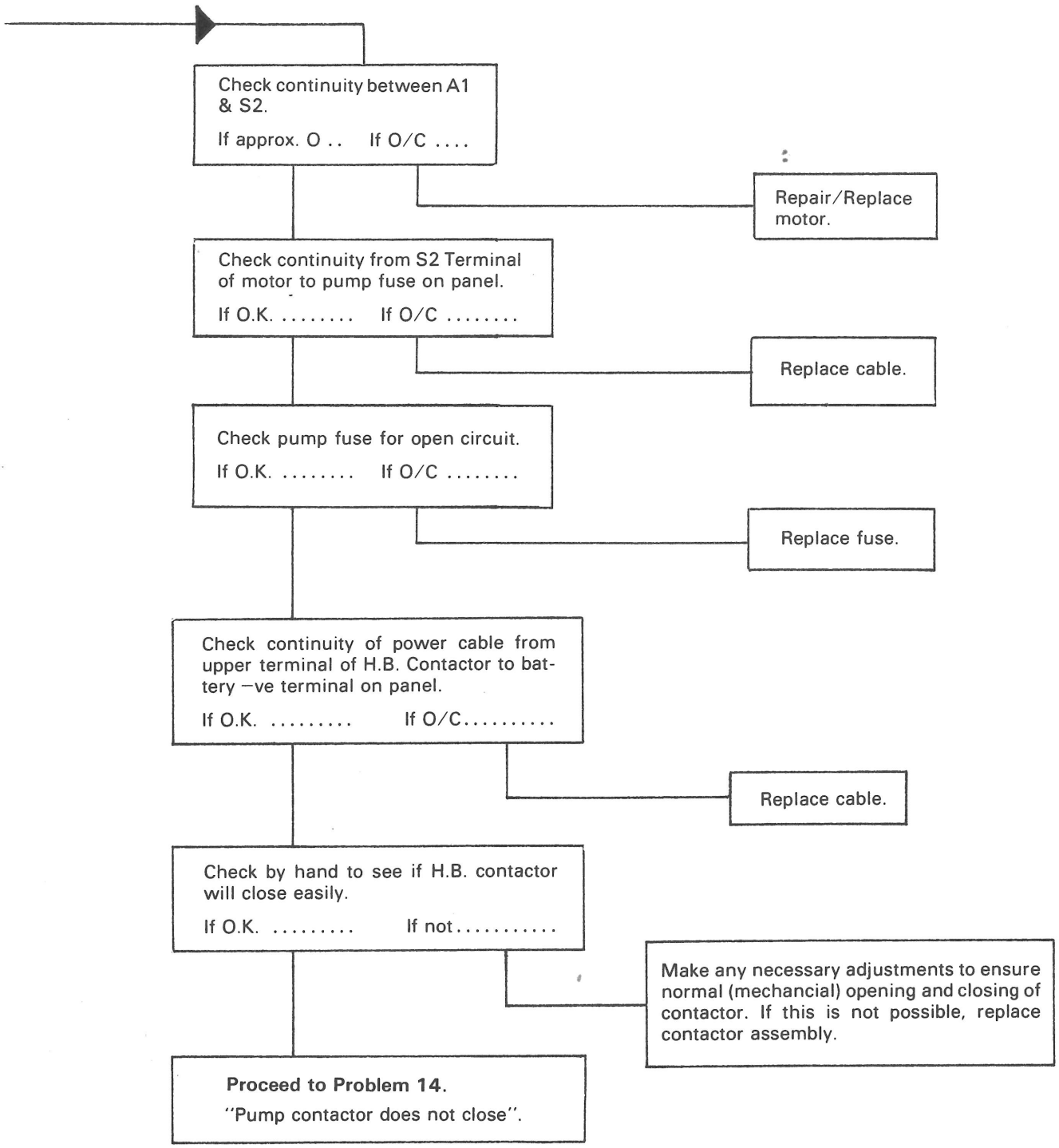
With battery disconnected check continuity of power cable from connector +ve to A1 terminal of motor.

If O.K. ..... If O/C.....

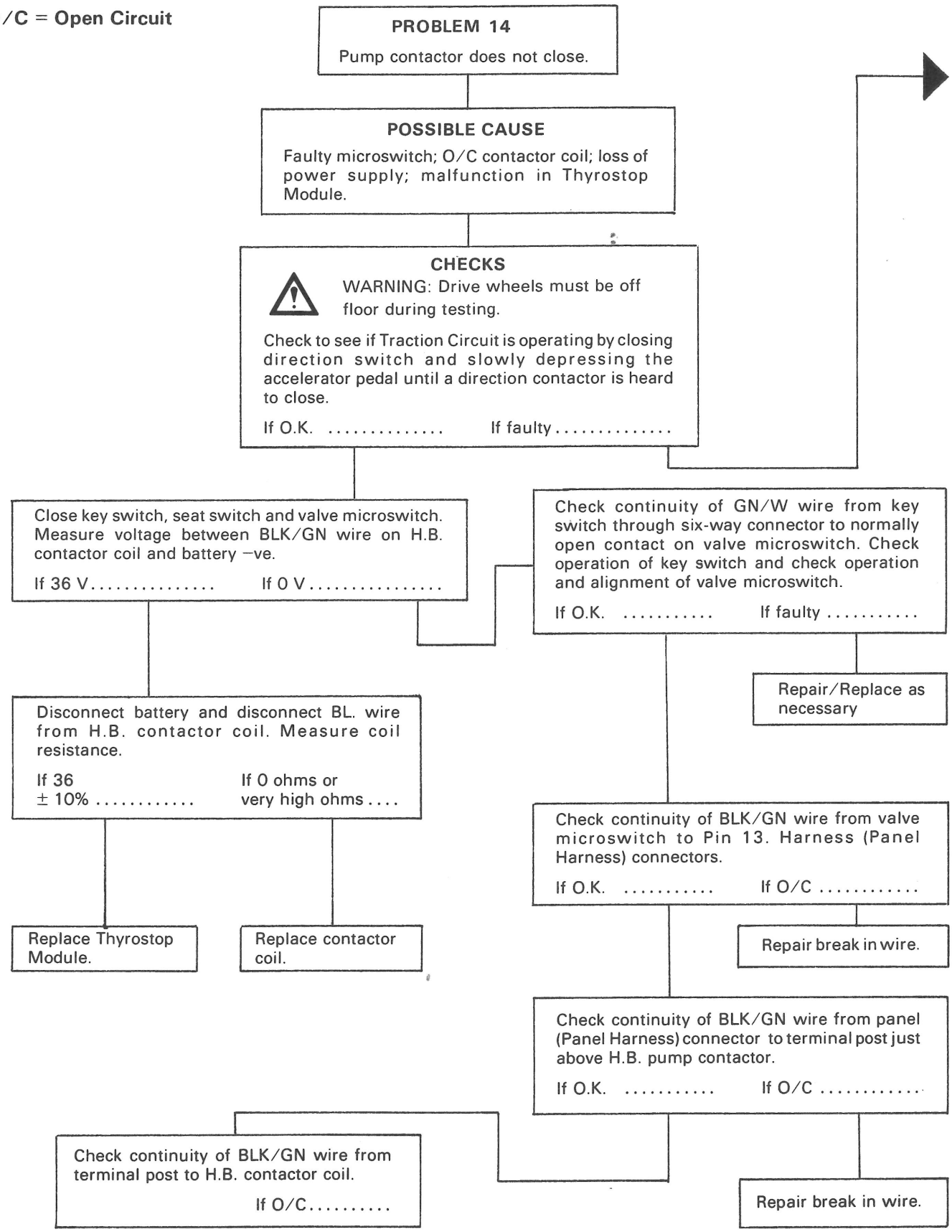
Replace cable.

Problem 13 (cont.)

O/C = Open Circuit

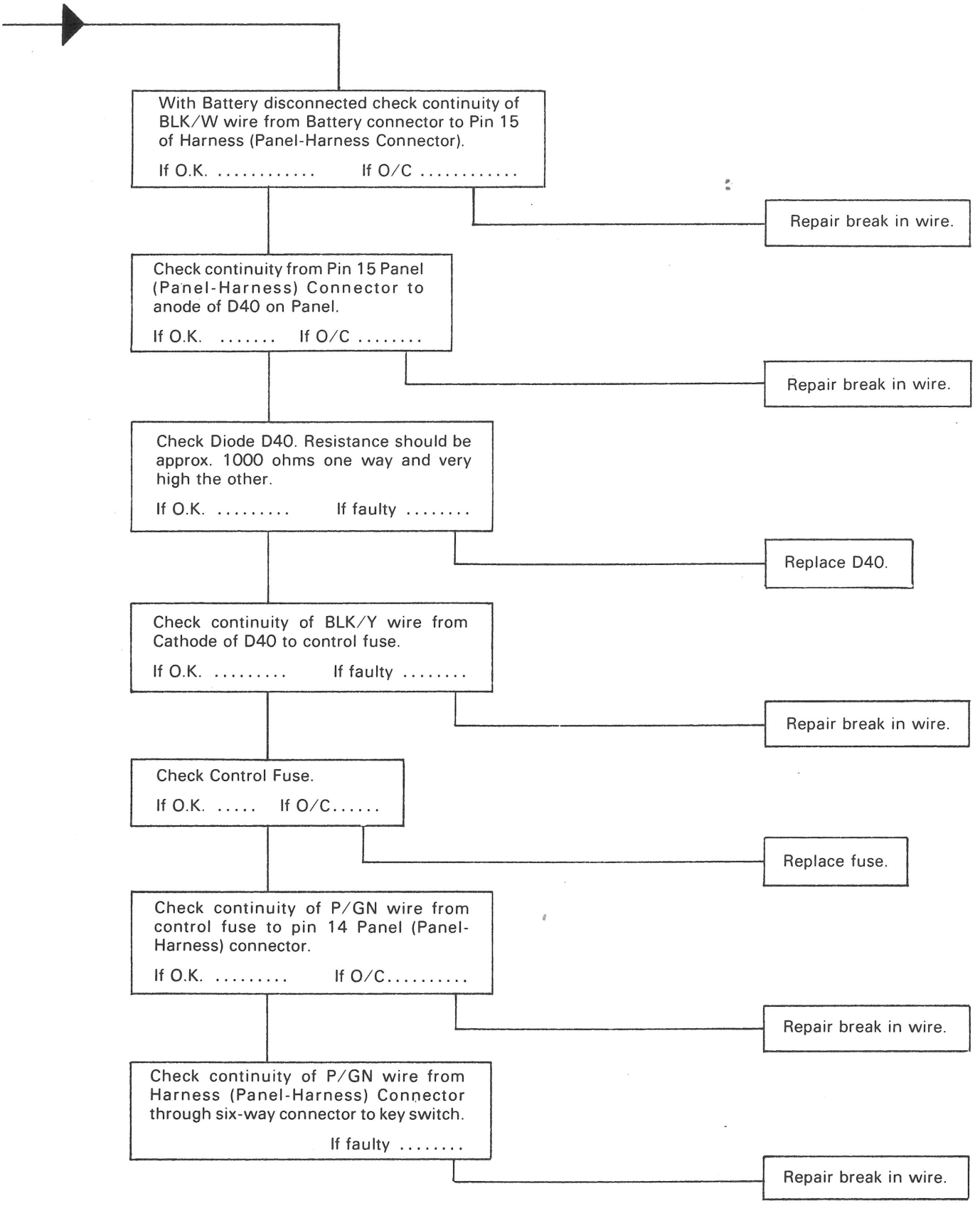

Check continuity between A1 & S2.
If approx. O .. If O/C ....
Repair/Replace motor.
Check continuity from S2 Terminal of motor to pump fuse on panel.
If O.K. ..... If O/C .....
Replace cable.
Check pump fuse for open circuit.
If O.K. ..... If O/C .....
Replace fuse.
Check continuity of power cable from upper terminal of H.B. Contactor to battery –ve terminal on panel.
If O.K. ..... If O/C.....
Replace cable.
Check by hand to see if H.B. contactor will close easily.
If O.K. ..... If not.....
Make any necessary adjustments to ensure normal (mechancial) opening and closing of contactor. If this is not possible, replace contactor assembly.
Proceed to Problem 14.
"Pump contactor does not close".

O/C = Open Circuit


PROBLEM 14
Pump contactor does not close.
POSSIBLE CAUSE
Faulty microswitch; O/C contactor coil; loss of power supply; malfunction in Thyrostop Module.
CHECKS
WARNING: Drive wheels must be off floor during testing.
Check to see if Traction Circuit is operating by closing direction switch and slowly depressing the accelerator pedal until a direction contactor is heard to close.
If O.K. ..... If faulty .....
Close key switch, seat switch and valve microswitch. Measure voltage between BLK/GN wire on H.B. contactor coil and battery –ve.
If 36 V..... If 0 V .....
Check continuity of GN/W wire from key switch through six-way connector to normally open contact on valve microswitch. Check operation of key switch and check operation and alignment of valve microswitch.
If O.K. ..... If faulty .....
Repair/Replace as necessary
Disconnect battery and disconnect BL. wire from H.B. contactor coil. Measure coil resistance.
If 36 ± 10% ..... If 0 ohms or very high ohms ....
Check continuity of BLK/GN wire from valve microswitch to Pin 13. Harness (Panel Harness) connectors.
If O.K. ..... If O/C .....
Replace Thyrostop Module.
Replace contactor coil.
Repair break in wire.
Check continuity of BLK/GN wire from panel (Panel Harness) connector to terminal post just above H.B. pump contactor.
If O.K. ..... If O/C .....
Check continuity of BLK/GN wire from terminal post to H.B. contactor coil.
If O/C.....
Repair break in wire.

PROBLEM 14 (cont.)

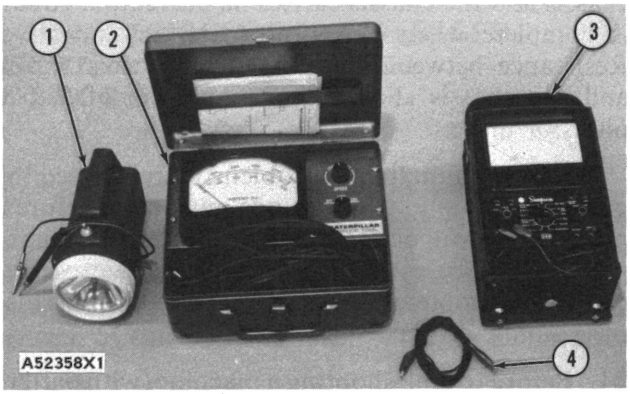
O/C = Open Circuit


With Battery disconnected check continuity of BLK/W wire from Battery connector to Pin 15 of Harness (Panel-Harness Connector).
If O.K. .....
If O/C .....
Repair break in wire.
Check continuity from Pin 15 Panel (Panel-Harness) Connector to anode of D40 on Panel.
If O.K. .....
If O/C .....
Repair break in wire.
Check Diode D40. Resistance should be approx. 1000 ohms one way and very high the other.
If O.K. .....
If faulty .....
Replace D40.
Check continuity of BLK/Y wire from Cathode of D40 to control fuse.
If O.K. .....
If faulty .....
Repair break in wire.
Check Control Fuse.
If O.K. .....
If O/C.....
Replace fuse.
Check continuity of P/GN wire from control fuse to pin 14 Panel (Panel-Harness) connector.
If O.K. .....
If O/C.....
Repair break in wire.
Check continuity of P/GN wire from Harness (Panel-Harness) Connector through six-way connector to key switch.
If faulty .....
Repair break in wire.

TESTING AND ADJUSTING

Test Equipment Needed:

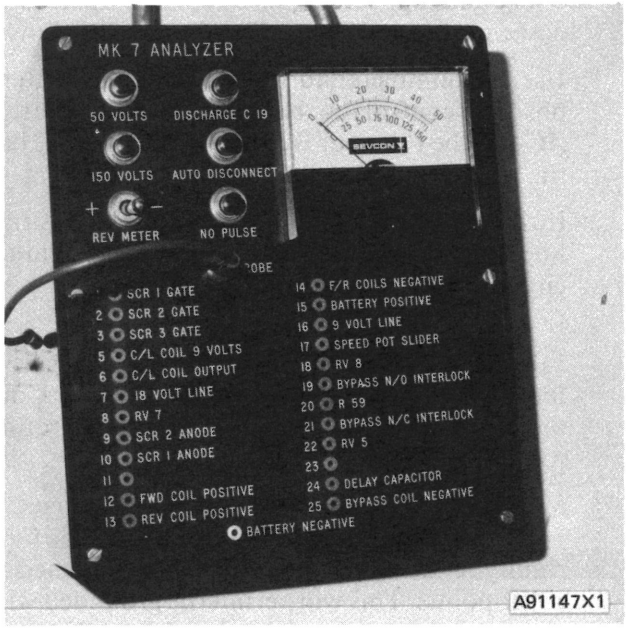
Multimeter.
6 Volt Circuit Tester (Continuity test light).
5P969 Ammeter Group or 2P5540 Ammeter Group.
Jumper Wire.
8S4627 Circuit Tester.



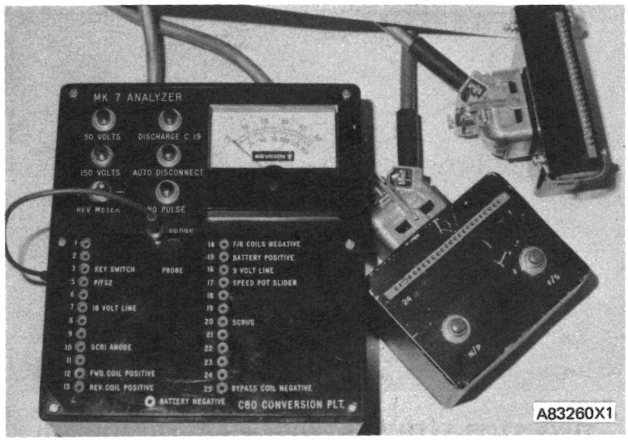
TEST EQUIPMENT

1. 6 volt circuit tester (continuity test light). 2. 5P969 Ammeter Group. 3. Multimeter. 4. Jumper wire.

NOTE: A MARK VII ANALYZER is available from Sevcon Corporation for Testing and Adjusting of the SCR Control System. Sevcon Mark VII Analyzer Handbook, Form No. SENB8040 gives instructions for its use as a test instrument by using the necessary adapters and conversion plate.



MARK VII ANALYZER



ANALYZER WITH CONVERSION PLATE INSTALLED AND ADAPTERS CONNECTED

GENERAL INFORMATION

Continuity (Complete Circuit) Tests

⚠ WARNING

Wait 1 1/2 minutes for Capacitor C19 to discharge before testing any components. Lift the front of the truck and install wood blocks safely on the frame so both drive wheels turn freely before the tests are made. Do not make contact with control panel or wiring until battery is disconnected and capacitor is discharged.

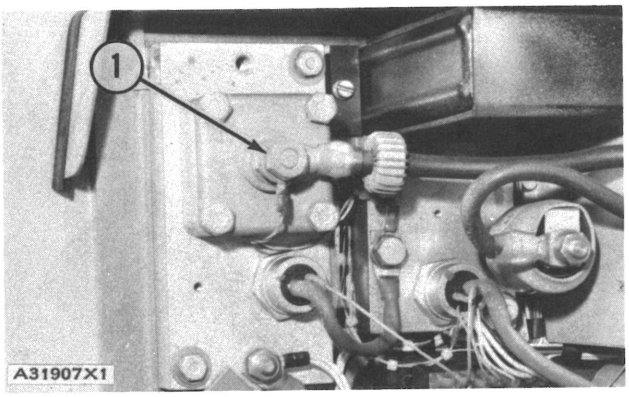
Either a Multimeter or a Circuit Tester can be used to do continuity tests where no specific resistance value is given. Use the lowest resistance scale when using a Multimeter. The indication must be near 0 ohms for a circuit with good continuity (complete circuit). If a Circuit Tester is used, the light will turn on bright if the circuit has good continuity.

NOTE: All wires must be as shown on the wiring diagram and schematic inside the door panel. Use the diagram and schematic as a reference to locate components by name, color code of wiring and number of terminals.

Voltage Checks

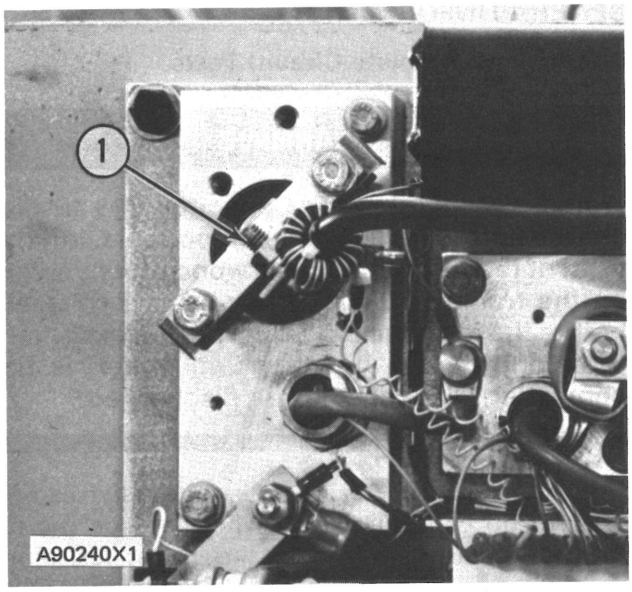
⚠ WARNING

When any voltage checks are made, the drive wheels of the truck must be off the floor and free to turn.



THYRISTOR 1 (TH1) CATHODE (EARLIER MODELS)
1. TH1 cathode.

1. Measure all voltages with the black (negative) multimeter wire connected to TH1 cathode (1).



THYRISTOR 1 (TH1) CATHODE (CURRENT MODELS)
1. TH1 Cathode.

2. When voltage checks are to be made on the Logic Unit, do the steps which follow:
   a. Remove the metal shield from the top of the control panel.
   b. Remove the cover from the Logic Unit.
   c. Use a very small probe with insulation that goes almost to its tip.
   d. Use care, do not short (connect together) the components or pins of the Logic Unit with the probe.
   e. Do not put pressure on the Logic Unit.

LOCATION OF GROUNDS

All Caterpillar Electric Lift Trucks use an electrical system that is not grounded (with ground connections). All current is carried by insulated conductors. No connections are made to the vehicle chassis and the chassis carries no current. A circuit is complete when it returns to battery negative. Resistance between any point in the truck wiring and the chassis should be a minimum of 50,000 ohms or more.

Many malfunctions (problems) are caused by grounds. Usually, two grounds must exist before a malfunction will occur. But, since batteries can have ground leakage, only one ground in the truck wiring can cause problems. To prevent problems because of grounds, do the following:

1. Before troubleshooting a machine (with battery disconnected and C19 discharged) check for, and clear any grounds. This will many times clear up, or may completely solve the problem or fault of the truck. Loose connections and insulation off wires is a problem sometimes.
2. Always keep batteries clean so as not to cause a ground by way of the battery.
3. Be sure that all attachments, such as horns and lights are designed for no ground connection, (a two-wire system).

Removal of Grounds

When a ground is found, it must be cleared even if the machine appears to have normal operation. To locate grounds, do the procedure that follows:

1. Use an ohmmeter to tell whether the battery positive (control fuse board) or battery negative (B—on the Pump or Bypass Contactor) line has the lower resistance to ground.
2. If the lower ground resistance is in the positive line, remove the fuses and check the individual circuits for grounds.
3. If the ground is in the negative line, remove the cable and wires from the battery negative terminal (B—on the Pump or Bypass Contactor). Check each of these wires for ground resistance.
4. When the lowest ground resistance circuit is located, it should be traced (checked for continuity, end-to-end) and if possible, opened at other points. This will permit the grounded wire or component to be pin-pointed (specific location) for repair or replacement.

It is almost impossible to locate grounds unless wires are disconnected. It is necessary to narrow the field of possible problem areas before inspection of individual wires and components.

NOTE: One source of a ground is dust from brush wear collected in the field windings of the motors.

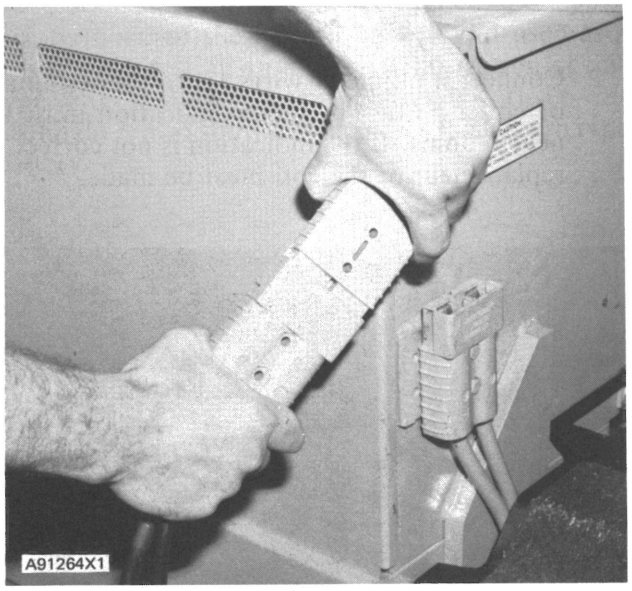
CONNECTING BATTERY CHARGER (Lift Trucks Equipped With SB or SBX Connector)

CAUTION

Connection of battery charger or rectified power (gasoline operated power supply) source to the control panel will cause damage.

Because the SB and SBX Connector halves are identical, it is possible to connect the battery charger or a rectified power source directly to the lift truck control panel. The AC voltage ripple (pulsing) from the battery charger or rectified power source will "blow" the control panel fuse. The fuse is in the circuit to give protection to the Logic Card.

It is recommended that all personnel be given instructions on the correct way to connect a battery charger or rectified power source to the battery. Also give all personnel warning of the damage that will be caused if the connection is made directly to the lift truck's control panel.



CORRECT WAY TO CONNECT BATTERY CHARGER

BATTERY TESTS

(See topic Better Battery Performance in Systems Operation section.)

Hydrometer Test

Test all of the cells across the battery with a hydrometer. If the specific gravity indication is below 1.140, the battery must be charged. The battery is fully charged if the indication is 1.265 to 1.285.

NOTE: If the indication between cells is different more than .015, the battery needs to be charged or have repairs made to it.

Check all cells for electrolyte level. Keep level 0.25 in. (0.64 mm) below the vent fill well. Fill to the correct level after a charge to prevent excess electrolyte spill during a charge. Add only "distilled" water to battery.

TESTING BATTERY WITH HYDROMETER

Battery Maintenance

The care and maintenance of batteries is of most importance if maximum battery life and most efficient truck operation are to be obtained. Periodic inspection and service will increase the life of batteries. We would suggest that special attention be given to the rules that follow:

1. Keep batteries clean at all times. Cleaning will prevent corrosion, current leakage and grounds. Tighten all vent plugs, wash battery with water, use an air hose to dry, and clean with a cloth. It may be necessary to use a sodium bicarbonate solution if water alone will not clean top of battery, then wash with water and a brush. Dry with an air hose.

2. Add water at regular intervals, enough water should be added to bring the electrolyte about .50 in. (12.7 mm) above the plates. This is a simple matter with the use of an automatic cell filler, which shows a light when the correct level has been reached. Water should always be added before charging to be sure thorough mixing with acid when gassing occurs near the end of charging period. Use distilled water or have the water supply analyzed.

   Charge battery correctly. It is important that all batteries be charged according to the manufacturers instructions. Most of the charging equipment is fully automatic and should be checked periodically. Never operate a truck with a fully discharged battery because this will cause damage to the contactors and motors.

3. Never overcharge a battery as this will damage the battery plates. Give the battery an equalizing charge at least once a week. An equalizing charge is an extra three or four hour charge at a low rate given after a normal charge, to make sure all cells are in fully charged condition. Regular battery readings should be taken with a hydrometer or voltmeter and a written record kept. Readings should never be taken directly after water has been added.

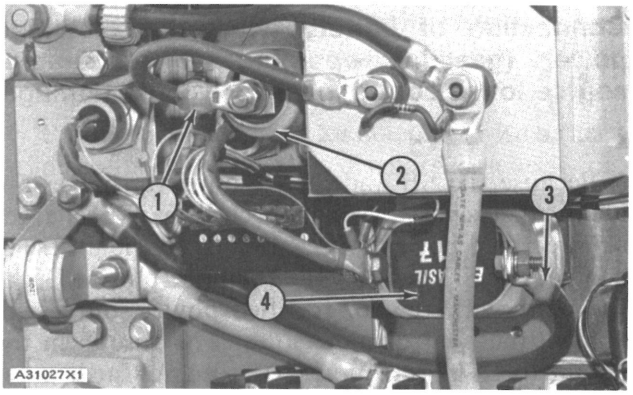
4. Keep accurate battery records. Case histories of batteries should be kept on record cards. Specific gravity and voltage of each cell should be checked and recorded at least once each month. This inspection should be made after an equalizing charge. Records of all battery maintenance should be made and filed so it will be known which batteries are being abused or wearing out.
   Repair should be made immediately otherwise the remainder of battery may become damaged.

5. When the specific gravity of a battery is above 1.200 the truck is usually good for another four hours of operation. If possible, it is a good idea to take battery reading every four hours. Changing a battery before it is completely discharged will save many hours of down time because of repairs. Do not follow the practice of running the battery down lower than 1.150 before recharging.

⚠ WARNING

Hydrogen and oxygen gases are given off as battery plates get near a full charge condition. These gases are highly explosive and caution must be taken to make sure no arc, spark, or flame comes into contact with the generated gases. The possibility of explosion is always present with exposure of the battery to sparks or flame, but is especially hazardous at the end of the charging period.

TESTING COILS L1 AND L2

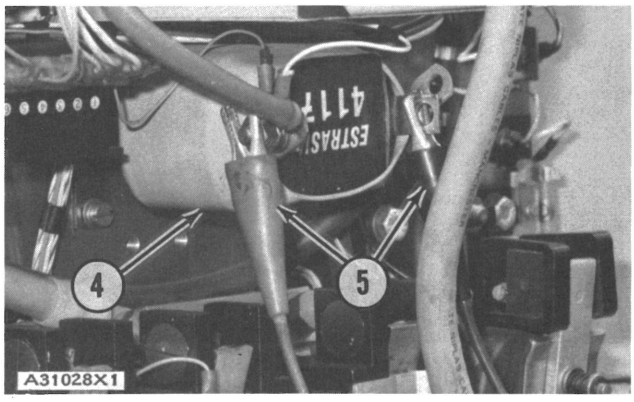


CONNECTIONS TO L1, L2

1. Cable. 2. Coil L2. 3. Cable. 4. Coil L1.

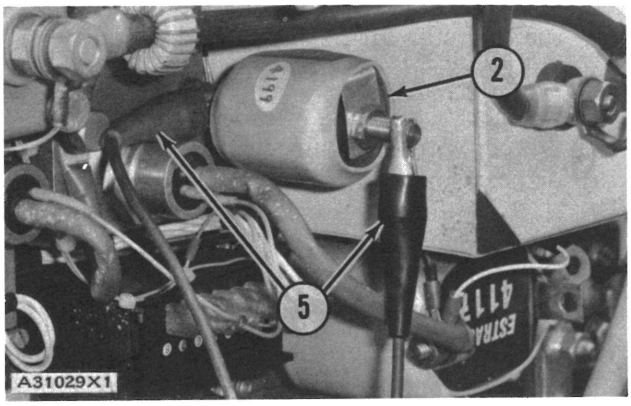
1. Disconnect cable (1) from coil L2 (2) and cable (3) from coil L1 (4).

2. Connect multimeter wires (5) to the terminals of coil L1 (4). The meter indication must be near 0 ohms. If the indication is not correct, a replacement of the coil must be made.



COIL L1 TEST

4. Coil L1. 5. Multimeter wires.



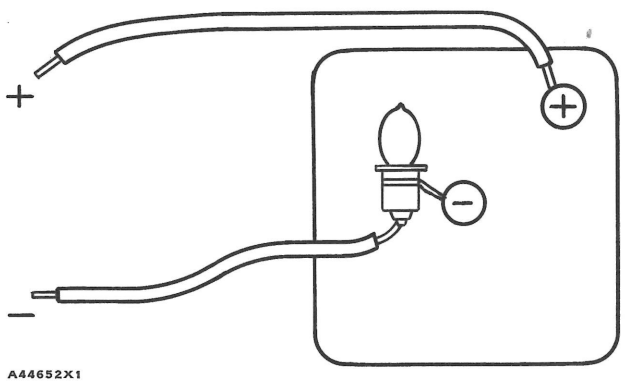
COIL L2 TEST

2. Coil L2. 5. Multimeter wires.

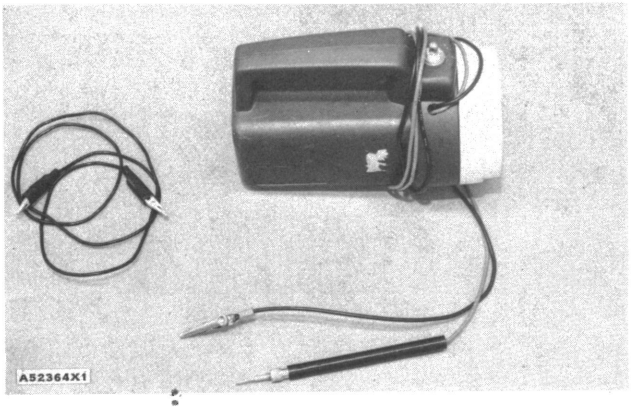
3. Connect multimeter wires (5) to the terminals of coil L2 (2). The multimeter indication must be near 0 ohms. If the meter indication is not correct a replacement of the coil must be made.

TESTING THYRISTORS WITH A TEST LIGHT

A test light can be made from a 6 volt lantern battery and a PR 12 flashlight bulb. The shell of the bulb must be fastened to the negative terminal of the lantern battery with a piece of wire. A piece of insulated wire must be soldered to the bottom contact of the PR 12 bulb and used as a test lead. A second piece of insulated wire must be fastened to the positive terminal of the lantern battery and used as a probe while testing an SCR. An illustration of this type tester is shown. A test light made with a 6 volt flashlight is also shown. It also uses the lantern type battery.



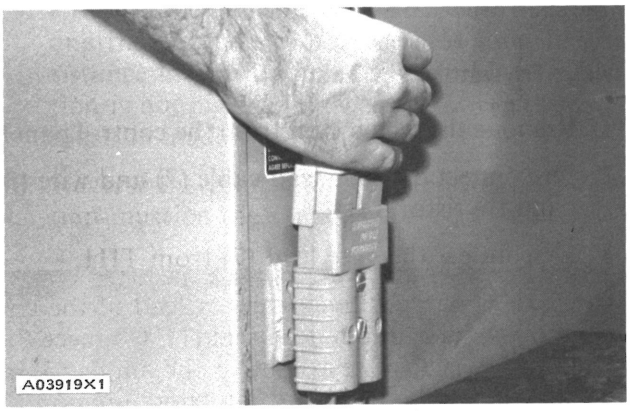
6 VOLT TEST LIGHT SCHEMATIC



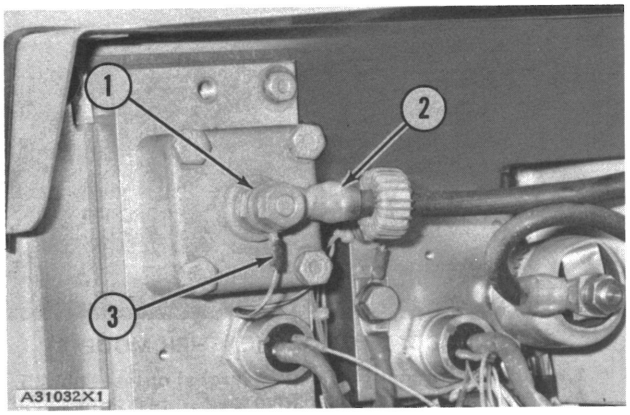
6 VOLT (FLASHLIGHT) TEST LIGHT AND JUMPER WIRE

⚠ WARNING

Disconnect the battery and let Capacitor discharge for 1 1/2 minutes before tests are made.

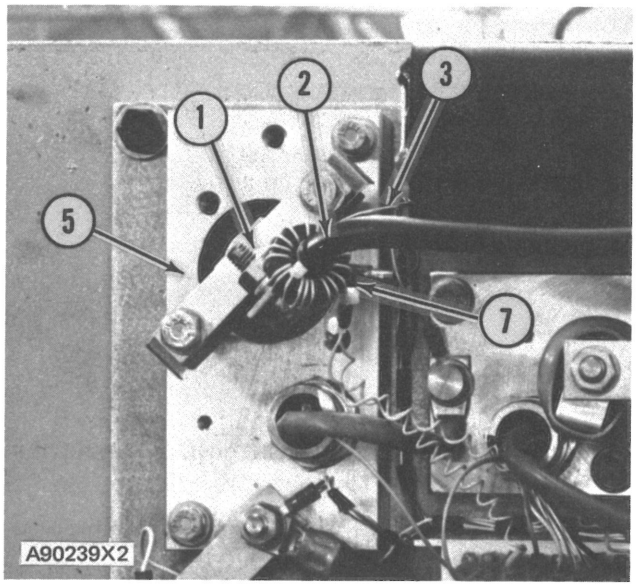


DISCONNECTING BATTERY



CONNECTIONS TO TH1 (EARLIER MODELS)

1. Cathode terminal. 2. Cable. 3. Wire. (Anode or the base is at heat sink).

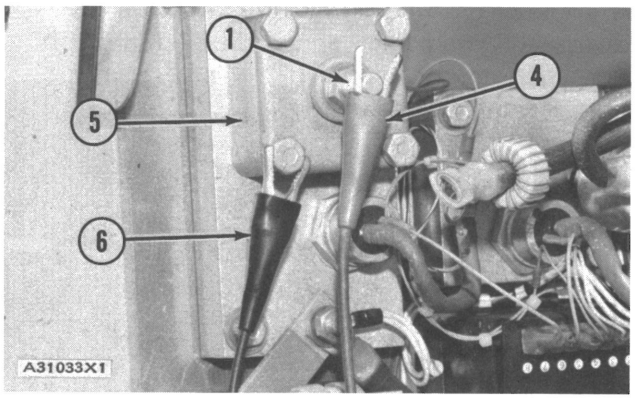


CONNECTIONS TO TH1 (CURRENT MODELS)

1. Cathode terminal. 2. Cable. 3. Wire. 5. Anode or base (heat sink). 7. Gate lead.

Main Thyristor TH1 Test

1. Remove the Logic Unit from the control panel.
2. Disconnect cathode lead cable (2) and wire (3) from thyristor TH1.
3. Disconnect the gate lead (7) from TH1.
4. Connect the positive probe or lead of the test light to the cathode terminal (1). Connect the negative lead of test light to the anode (5) or heat sink. The test light must not come on.



TH1 TEST CONNECTIONS (EARLIER MODELS)

1. Cathode terminal. 4. Positive (probe) of test light. 5. Anode or heat sink. 6. Negative lead of test light.

5. Connect the leads of the test light in reverse of Step 4. The light must not come on. If the light comes on now or in Step 4, the thyristor has a short and must be replaced.
6. If the tests of Steps 4 and 5 are acceptable, test the thyristor for its ability to fire (turn on) by the gate lead (7).
7. Connect the test light leads as in Step 5. Use a jumper wire and connect one end to the anode or heat sink and connect the other end to gate lead of the thyristor. If the gate has correct operation, the test light will come on and stay on when the gate jumper lead is removed.
8. If the test light will not come on with the test of Step 7, the thyristor has an open circuit and must be replaced.

NOTE: If the thyristor checks good, then continuity of the gate lead wires must be checked back to the Logic Module to make sure the Thyristors receive the signal.

Thyristors TH2, TH3 Test

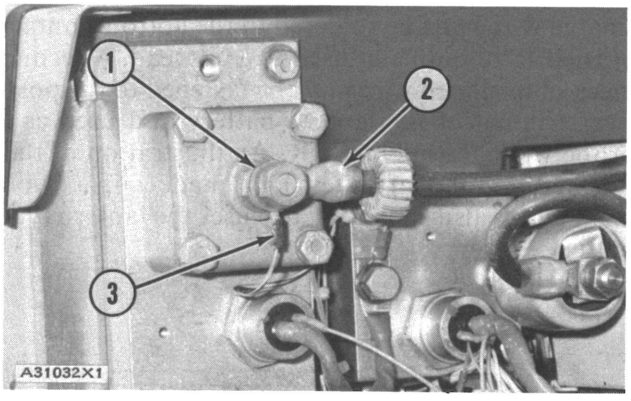
1. Do the same procedures as for the main thyristor TH1 test.

TESTING THE THYRISTORS WITH MULTIMETER

Main Thyristor (TH1)

⚠ WARNING

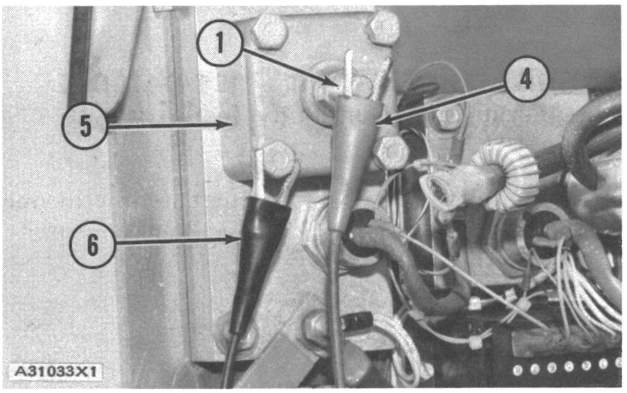
Disconnect the battery. Let the capacitor discharge for 1 1/2 minutes.



CONNECTIONS TO TH1

1. Cathode terminal. 2. Cable. 3. Wire.

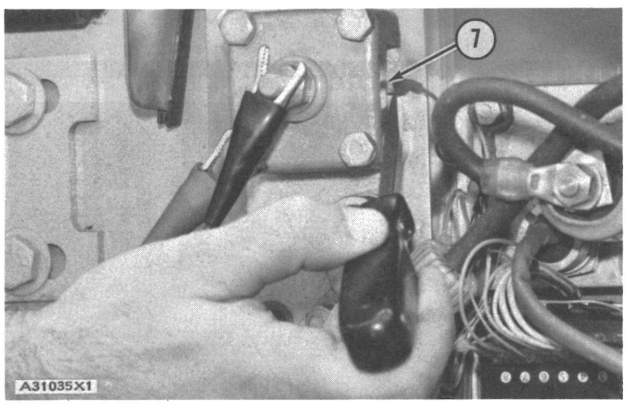
1. Remove the Logic Unit from the control panel.
2. Disconnect cable (2) and wire (3) from cathode terminal (1) of TH1.



TH1 TEST CONNECTIONS

1. Cathode terminal. 4. Positive (red) wire to multimeter. 5. Heat sink (anode of TH1). 6. Negative (black) wire to multimeter).

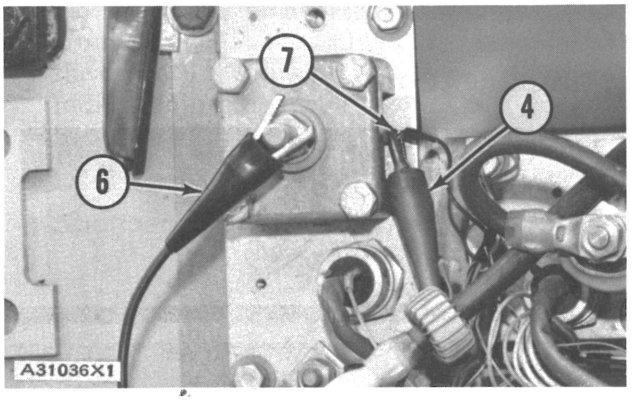
3. Connect positive (Red) wire (4) to cathode terminal (1) and negative (black) wire (6) to heat sink (anode of TH1) (5). Use the RX100 scale on the multimeter. The indication must be approximately 1 Meg ohm. If the indication is low (near 0 ohms) the thyristor has a defect (shorted).
4. Reverse the connections to the multimeter. The indication must be the same as in Step 3.



TH1 GATE TEST (A)

7. Gate.

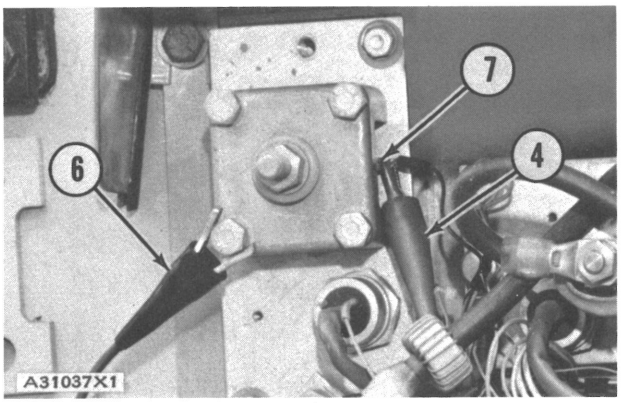
5. Keep the wires to the multimeter connected as in Step (4).
6. Connect (short) gate (7) to the heat sink with a metal object such as a screwdriver.
7. The resistance indication on the multimeter must change to a low value. If the indication does not change, the gate has a defect and the thyristor must be replaced.



TH1 GATE TEST (B)

4. Positive (red) wire to multimeter. 6. Negative (black) wire to multimeter. 7. Gate.

8. Connect the multimeter positive wire (4) to gate (7) and negative wire (6) to the cathode of TH1. The resistance indication must be low. If the indication is not correct, the gate is open and the thyristor must be replaced.
9. Connect the multimeter positive wire to gate (7) and the negative wire to the heat sink. The resistance indication must be high. If the indication is not high, a replacement of the thyristor must be made.
10. Reverse the connections in Step 9. The indication must be the same.



TH1 GATE TEST (C)

4. Positive (red) wire to multimeter. 6. Negative (black) wire to multimeter. 7. Gate.

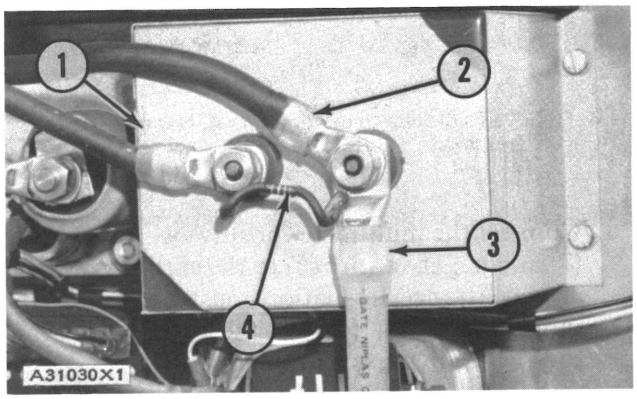
Thyristor TH2 and TH3 Test

1. Use the same procedure as for thyristor TH1 Test.

TESTING CAPACITOR C19

⚠ WARNING

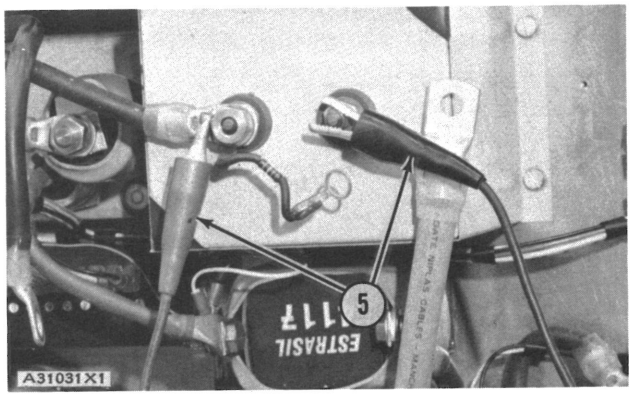
Disconnect the battery. Let the capacitor discharge for 1 1/2 minutes.



CONNECTIONS TO CAPACITOR C19

1. Capacitor C19. 2. Cable. 3. Cable. 4. Resistor.

1. Disconnect cable (2), cable (3) and resistor (4) from the terminal of C19 capacitor (1).



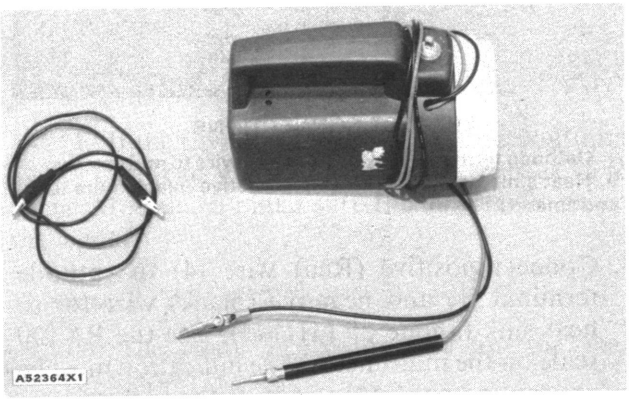
CAPACITOR C19 TEST

5. Multimeter wires.

2. Connect multimeter wires (5) to the capacitor terminals. Use the RX10,000 scale on the multimeter. If the capacitor does not have a defect, the multimeter indication will first be 0 ohms and then increase to a value above 100,000 ohms.

TESTING MAIN POWER DIODES D41, D42
With A Test Light (Continuity Tester)

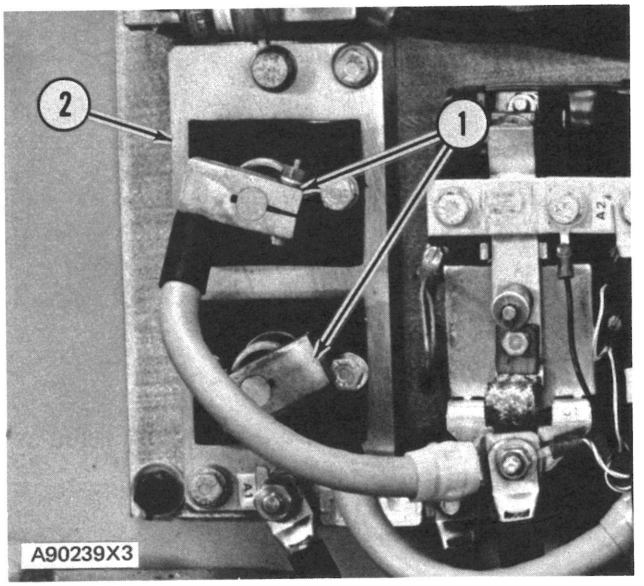
NOTE: Diodes 41 and 42 let current flow in one direction only. Use the 6 Volt Test Light (continuity Tester) for this test.



6 VOLT (FLASHLIGHT) TEST LIGHT

⚠ WARNING

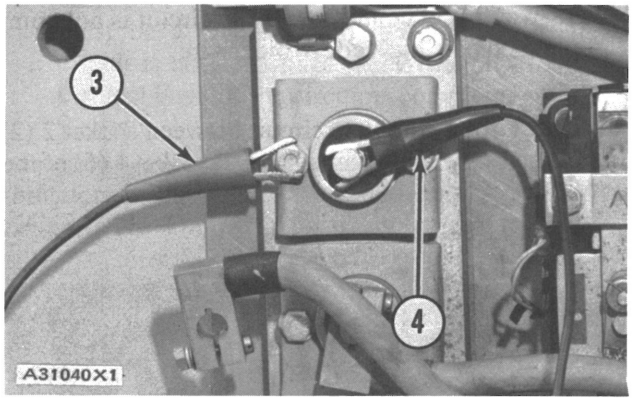
Disconnect battery and let capacitor C19 discharge for 1 1/2 minutes before any test is made.



DIODES D41 AND D42

1. Anode leads for D41 and D42. 2. Cathode or heat sink for both diodes.

1. Disconnect the anode lead from the diode to be tested.



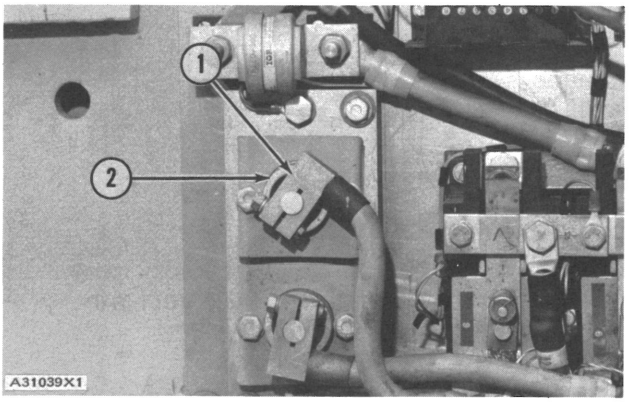
DIODE TEST WITH TEST LIGHT

3. Positive probe or lead. 4. Negative lead.

2. Connect the lead (negative) wire of the test light to the anode of the diode. Connect the probe (positive) of the test light to the cathode. The test light must not come on. If the bulb of the test light comes on, the diode must be replaced.
3. Connect the lead wire (4) of the test light to the cathode. Connect the probe (3) of the test light to the anode. If the diode has correct operation, the bulb of the test light will come on (light).

TESTING MAIN POWER DIODES D41-D42 FOR SHORTS AND OPENS

With Multimeter



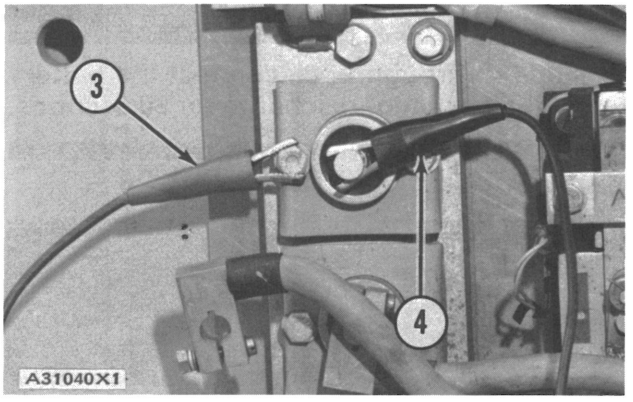
CONNECTIONS TO DIODE D41

1. Anode lead. 2. Diode D41.

⚠ WARNING

Disconnect battery and let capacitor C19 discharge for 1 1/2 minutes before any test is made.

1. Disconnect the anode lead from the diode.
2. Turn the multimeter switch to the RX1 scale. Connect one multimeter wire to the anode and the other to the cathode and make a note of the indication on the meter.



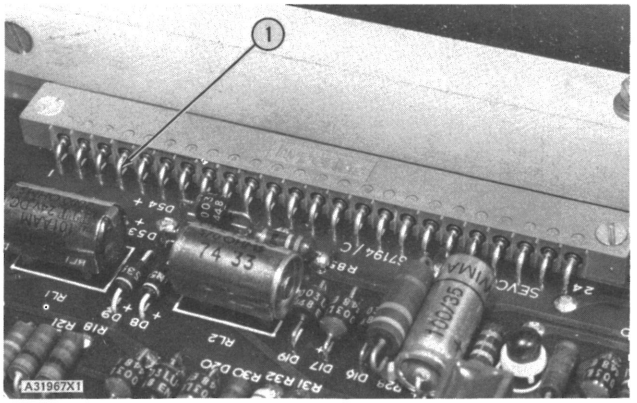
DIODE TEST WITH MULTIMETER

3. Positive multimeter wire. 4. Negative multimeter wire.

3. Reverse the wires and read the indication on the multimeter. One indication must be high resistance and the other low resistance.
4. If the diode has a short, there will be a low resistance indication in both directions. If the diode is open there will be an infinite resistance in both directions. Replace the diode if either condition is present.

TESTING THE MAIN VOLTAGE SUPPLY TO THE LOGIC UNIT

1. See the GENERAL INFORMATION, Voltage Checks section of TESTING AND ADJUSTING before this procedure is started.



LOGIC UNIT PINS

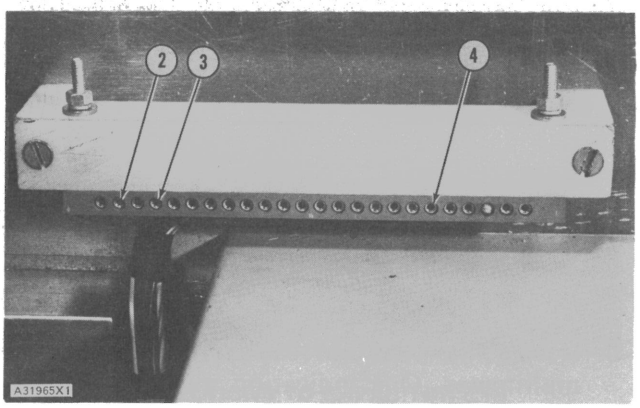
1. Pin 4.

2. Connect the negative (black) multimeter wire to the cathode of TH1.

3. Measure the voltage at pin 4 (1) of the Logic Unit with the Key Switch in the ON position. The voltage must be 18 volts. If the voltage is not correct, go to Step 4.

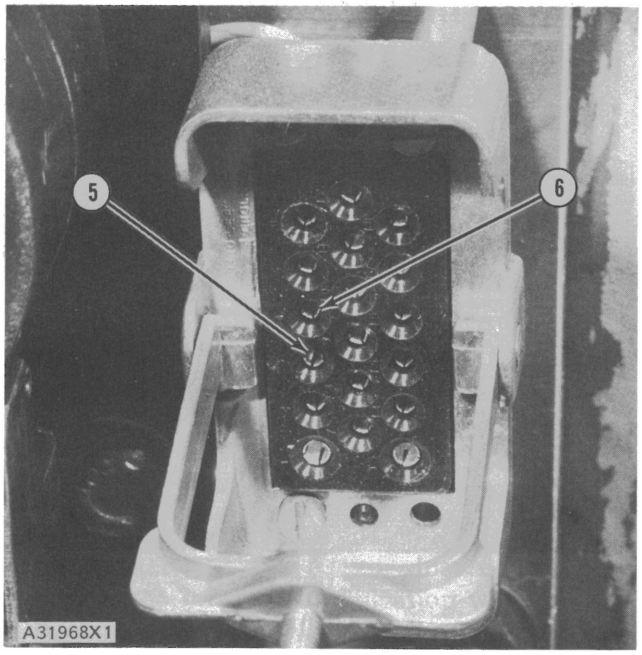
⚠ WARNING

For steps 4 through 9, disconnect the battery and let the capacitor discharge for 30 seconds.



LOGIC UNIT CONNECTOR
2. Socket 2. 3. Socket 4. 4. Socket 19.

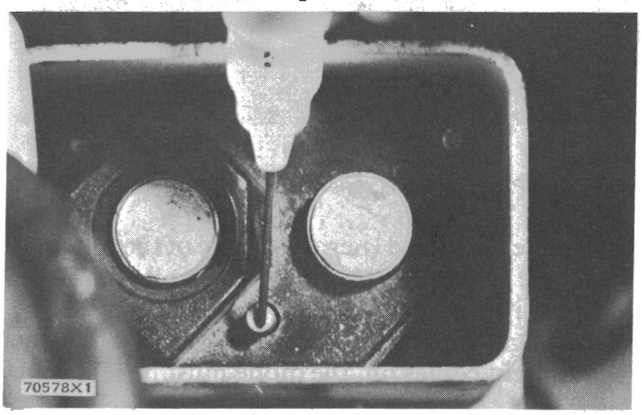
4. Check for a complete circuit between socket 19 (4) of the Logic Unit connector and the cathode of TH1. Repair the defect if the circuit is not complete. If the circuit is complete, go to Step 5.



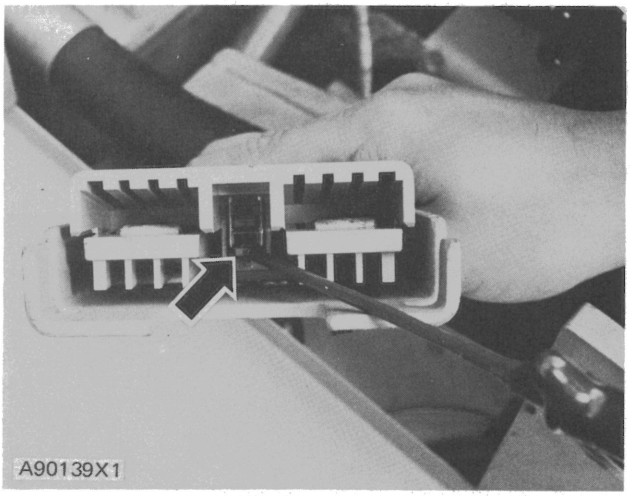
18 WAY PANEL CONNECTOR
5. Socket 3. 6. Socket 4.

5. Check for a complete circuit between socket 4 (3) of the Logic Unit connector and socket 3 (5) of the 18-way panel connector. If the circuit is not complete, repair the yellow/blue wire.

6. Check for a complete circuit between socket 2 (2) of the Logic Unit connector and socket 4 (6) of the 18-way panel connector. If the circuit is not complete repair the green/white wire. If the circuit is complete, go to Step 7.



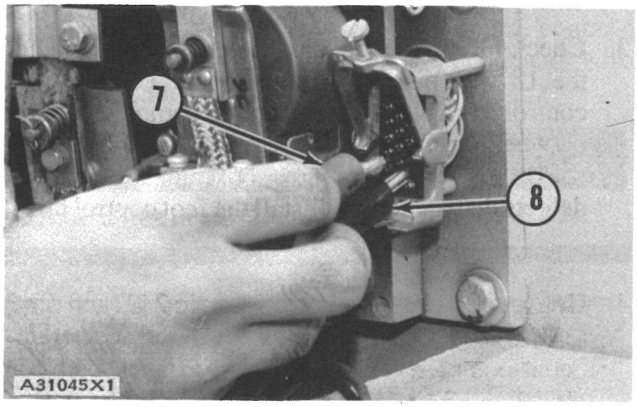
BATTERY CONNECTOR — 36 VOLT TAP (EARLIER MODELS)



BATTERY CONNECTOR — 36 VOLT TAP (CURRENT MODELS)

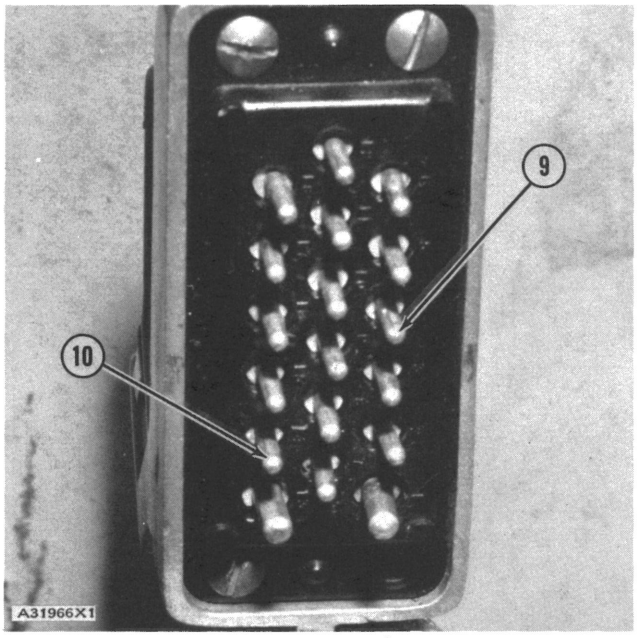
7. Disconnect the battery connector and check for a complete circuit between pin 15 of the 18 way panel connector plug and the 36 volt tap at the battery connector. If the circuit is not complete, repair the defect. If the circuit is complete, go to Step 8.

8. Connect the red (positive) multimeter wire (7) to socket 15 and the black multimeter wire (8) to socket 14 of the 18 way panel connector. There must be a complete circuit (continuity). If the circuit is not complete, check diode D40 and the Control Fuse. If the circuit is complete, go to Step 9.



18 WAY PANEL CONNECTOR TEST CONNECTIONS

7. Red (positive) multimeter wire. 8. Black (negative) multimeter wire.



18 WAY PANEL PLUG

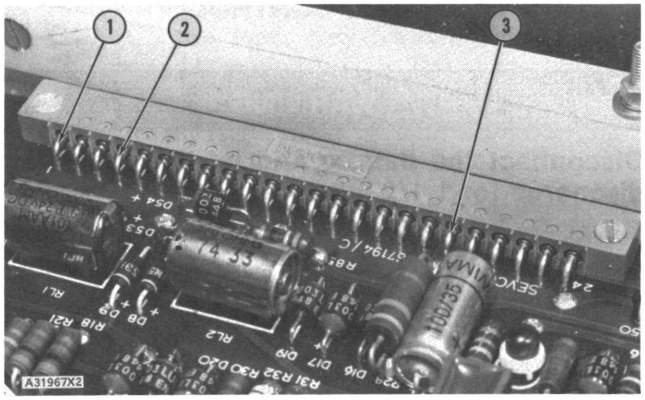
9. Pin 4. 10. Pin 14.

9. With Key Switch in the ON position, check for a complete circuit between pin 4 (9) and pin 14 (10) on the 18 way panel plug. If the circuit is not complete, find the problem and repair it. If the circuit is complete, replace the Logic Unit.

TESTING THE 9 VOLT SUPPLY FROM THE LOGIC UNIT

1. See the GENERAL INFORMATION, Voltage Checks section of TESTING AND ADJUSTING before this procedure is started.

2. Connect the multimeter black (negative) wire to TH1 cathode. Measure the voltage at pin 1 (1) of the Logic Unit. With the Key Switch in the ON position the voltage must be 9 volts. If the voltage is not correct, go to Step 3.



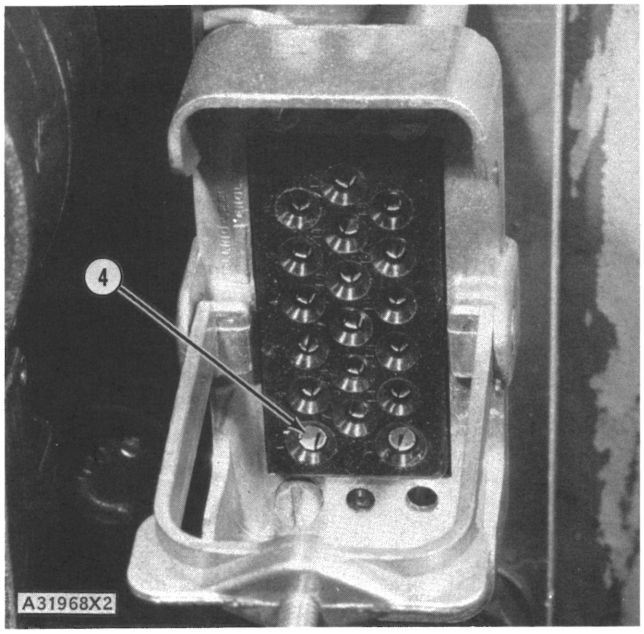
LOGIC UNIT PINS

1. Pin 1. 2. Pin 4. 3. Pin 19.

3. Measure the voltage at pin 4 (2) of the Logic Unit. If 18 volts is present, go to Step 4. If 9 volts is present, change the Logic Unit. If the voltage is 0 volts, go to the TESTING THE MAIN VOLTAGE SUPPLY TO THE LOGIC UNIT section of TESTING AND ADJUSTING.

⚠ WARNING

For Steps 4 and 5 disconnect battery and let capacitor C19 discharge for 1 1/2 minutes.



18 WAY PANEL CONNECTOR

4. Socket 1.

4. Check for a complete circuit between pin 1 (1) of the Logic Unit and socket 1 (4) of the 18 way panel connector. If the circuit is not complete, repair the defect. If the circuit is complete, go to Step 5.

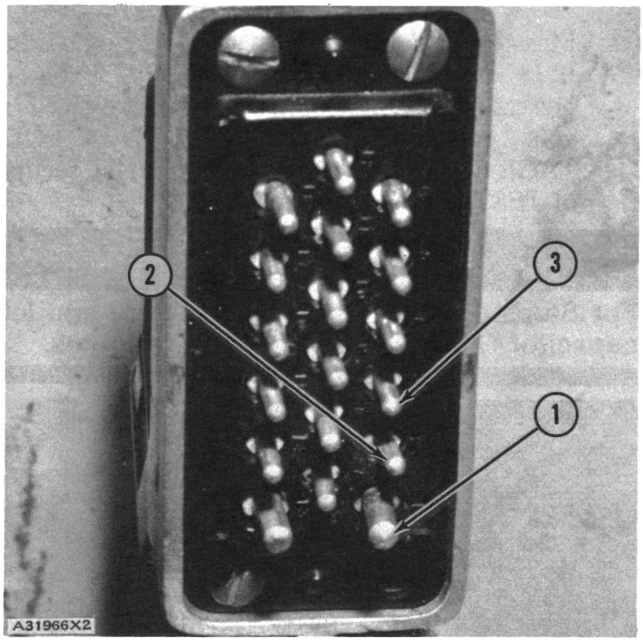
5. Check for a complete circuit between pin 19 (3) of the Logic Unit and TH1 cathode. If the circuit is not complete, repair the circuit. If the circuit is complete, replace the Logic Unit.

TESTING THE SPEED CONTROL CIRCUIT

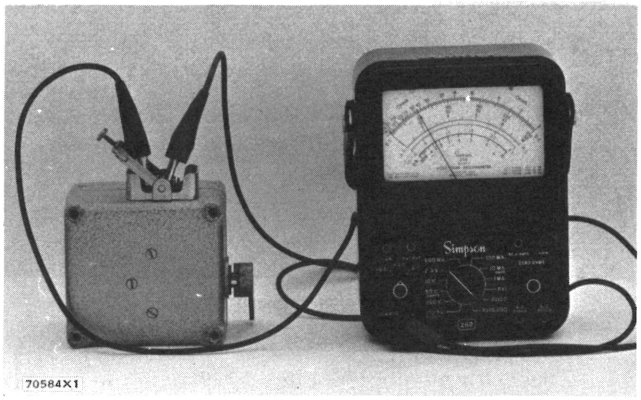
⚠ WARNING

Disconnect the battery and let the capacitor discharge for 1 1/2 minutes.

1. Connect the multimeter wires to pin 1 (1) and pin 3 (3) of the 18 way panel plug. Measure the resistance between pins 1 and 3 (use the RX100 scale). The resistance must be 5000 ohms ± 10%. If the resistance is not correct, go to Step 2. If the resistance is correct go to Step 4.



18 WAY PANEL PLUG
1. Pin 1. 2. Pin 2. 3. Pin 3.

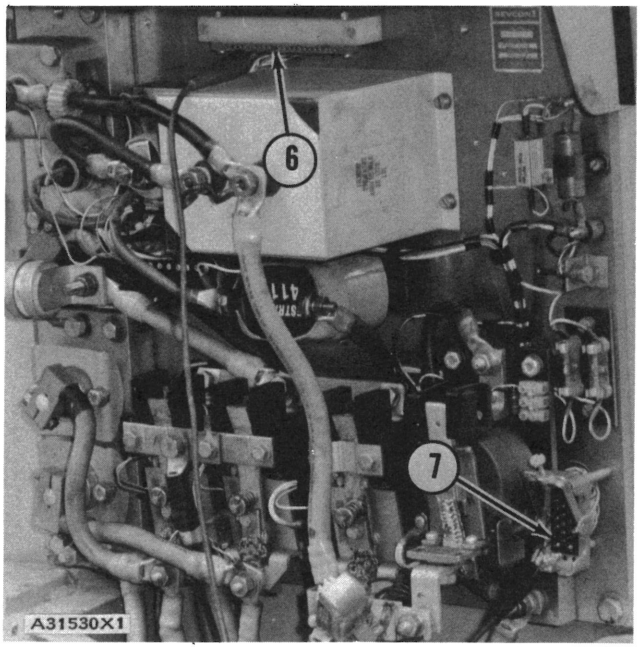


FOOT CONTROL BOX CHECK
4. Foot control box. 5. Multimeter.

2. Remove foot control box (4). Measure the resistance between pins 1 and 3 on the foot control box. The potentiometer can be in any position. The resistance must be 5000 ohms ± 10%. If the resistance is not correct, change the foot control box. If the resistance is correct, go to Step 3.

3. Check for a complete circuit between pin 1 (1) of the 18 way panel plug and socket 1 of the foot control box plug. Check for a complete circuit between pin 3 (3) of the 18 way panel plug and socket 3 of the foot control box plug. Repair any defects that are found. Install the foot control box.

4. Connect the multimeter wires to pin 2 (2) and pin 3 (3) of the 18 way panel plug. Push the accelerator pedal completely down. The resistance between pins 2 and 3 must go from 0 to 5000 ohms as the accelerator pedal is moved. If the resistance is not correct, go to the section ADJUSTING THE FOOT CONTROL POTENTIOMETER. If the resistance is correct, go to Step 5.



CIRCUIT CHECK
6. Socket 12. 7. Socket 2.

5. Check for a complete circuit between socket 12 (6) of the Logic Unit connector and socket 2 (7) of the 18 way panel connector. If the circuit is not complete, repair or replace the bluewhite wire. If the circuit is complete, replace the Logic Unit.

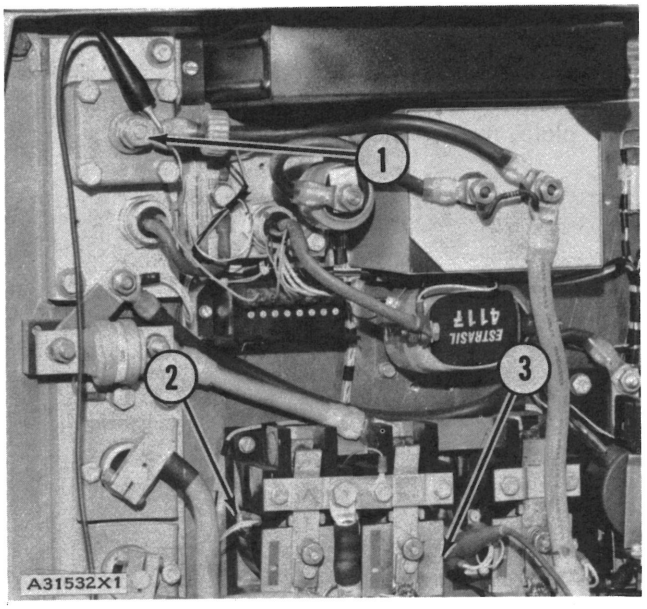
TESTING THE FORWARD AND REVERSE CONTACTOR COILS

1. See the GENERAL INFORMATION, Voltage Checks section of TESTING AND ADJUSTING before this procedure is started.

2. Operate the truck with the wheels off of the floor to see if either contact will close. If only one contactor will close, go to Step 3. If neither contactor will close, go to Step 5.

⚠ WARNING

Drive wheels must be raised off the floor.



CONTACTOR VOLTAGE CHECKS

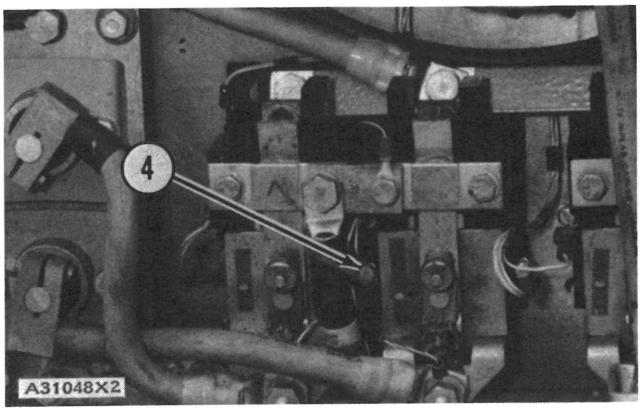
1. TH1 cathode. 2. Pink wire. 3. Brown/white wire.

3. Connect the black (negative) multimeter wire to TH1 cathode (1). Measure the voltage at pink wire (2) if the Forward contactor will not close. Measure the voltage at the brown/white wire (3) if the Reverse contactor will not close. Be sure that the Key Switch, the Hand Brake Switch, the Foot Switch, and the Direction Switch are in the correct positions before the voltage measurements are made. 36 volts must be present at each test point. If no voltage is present go to Step 4. If the correct voltage is present, check the contactor coil for the correct resistance. Be sure to disconnect the battery first. The resistance must be from 38 to 45 ohms.

4. Disconnect the battery and let the capacitor discharge for 1 1/2 minutes. Check the continuity of the pink or the brown/white wire. Check from the Direction Switch to the Contactor Panel. Make any repairs that are necessary.

5. Measure the voltage at pink wire (2) on the Forward contactor, be sure that the switches are in the correct positions. If 0 volts is found go to Step 6. If 36 volts is found, go to Step 7.

6. Measure the voltage at the Battery connector tap, D40, Control fuse, Key Switch, Hand Brake Switch, and Direction Switch. The correct voltage (36 volts) must be present at all points when the Key Switch, Hand Brake Switch, and Foot Control Switch are closed.



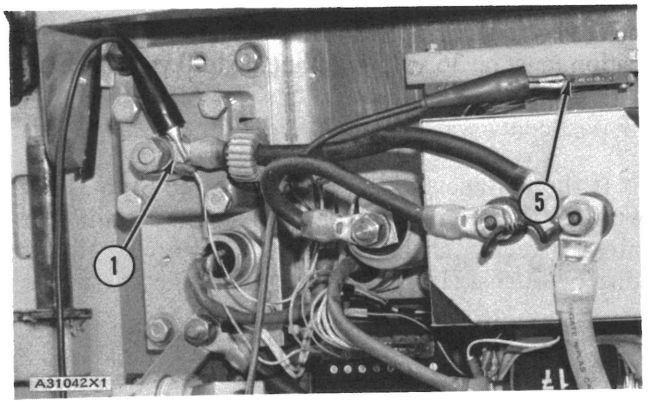
CONTACTOR VOLTAGE CHECK

4. Orange/white wire.

7. Measure the voltage at orange/white wire (4) on the contactors. 36 volts must be present if the voltage is not correct check the contactor coils for open circuits. If the voltage is correct, go to Step 8. The correct resistance of the contactor coils is 38 to 45 ohms.

⚠ WARNING

Let capacitor discharge for 1 1/2 minutes after battery is disconnected.



CIRCUIT CHECK

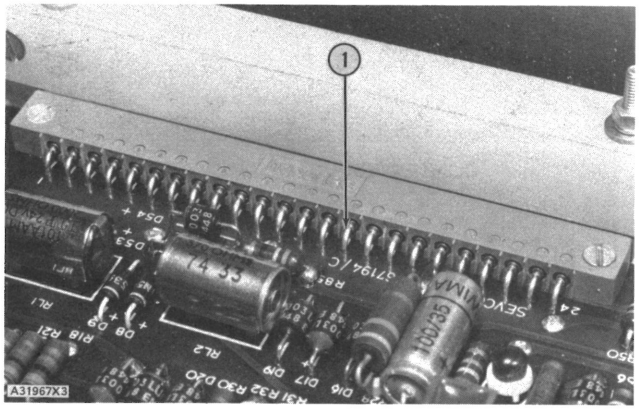
1. TH1 cathode. 5. Socket 19.

8. Check the Direction and Bypass contactors for welded tips. If the tips are welded, break the welds (replace if necessary). If the tips are not welded, go to Step 9.

9. Check for a complete circuit between TH1 cathode (1) and socket 19 (5) of the Logic Unit connector. If the circuit is not complete, repair the black wire. If the circuit is complete, replace the Logic Unit.

TESTING THE BYPASS CONTACTOR CIRCUIT

1. See the GENERAL INFORMATION Voltage Checks section of TESTING AND ADJUSTING before this procedure is started.



LOGIC UNIT PINS

1. Pin 15.

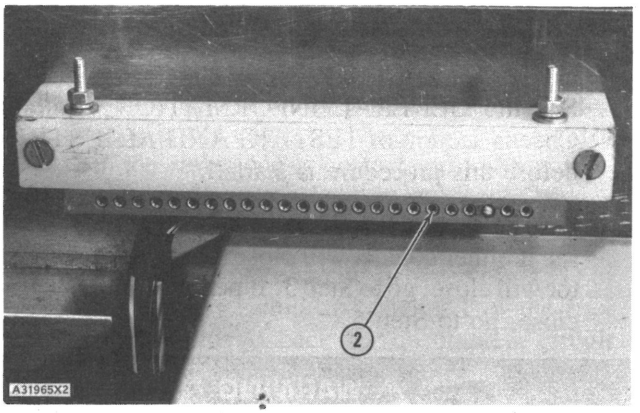
2. Connect the multimeter black (negative) wire to TH1 cathode. Connect the positive (red) wire to pin 15 (1) of the Logic Unit.

Activate the Key and the Hand Brake Switches. Put the Direction Control in forward and push the accelerator pedal completely down. The multimeter indication must be 36 volts and then go to 0 volts when the Bypass contactor activates. The time delay before the Bypass contactor activates is approximately 2 seconds.

If the voltage stays at 36 volts, go to Step 3. If no voltage is present, go to Step 4. If the circuit operates correctly, check the Bypass contactor tips for dirt or burns. (Repair or replace as necessary).

⚠ WARNING

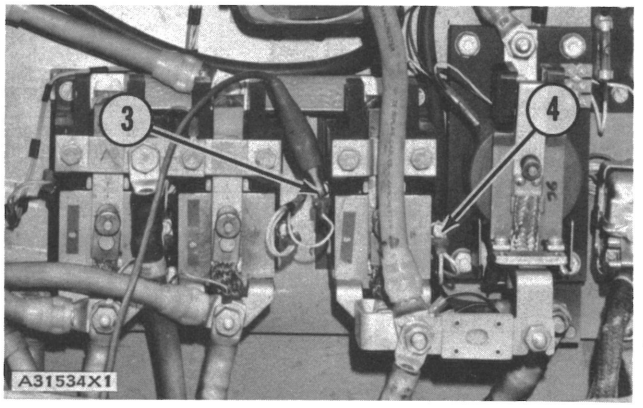
Before Step 3 is started, disconnect the battery and let the capacitor discharge for 1 1/2 minutes.



LOGIC UNIT CONNECTOR

2. Socket 19.

3. Remove the Logic Unit and check for a complete circuit between socket 19 (2) and TH1 cathode. If the circuit is not complete, repair the wire between socket 19 and TH1 cathode. If the circuit is complete, replace the Logic Unit.

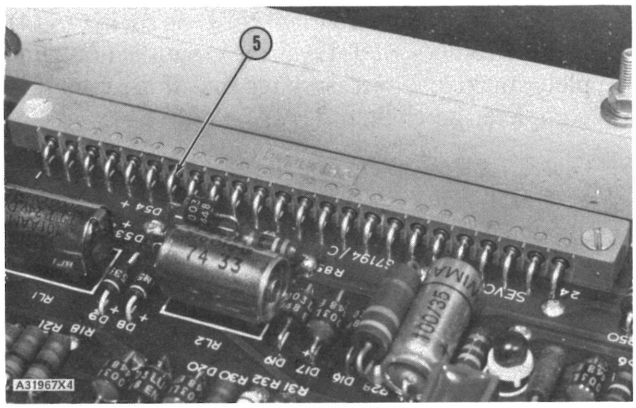


BYPASS CONTACTOR

3. Green/yellow wire. 4. Pink/orange wire.

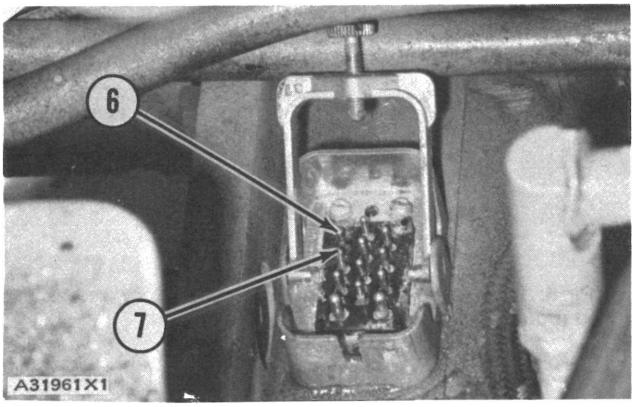
4. Put all the switches and the accelerator pedal in the same positions as in Step 2. Measure the voltage at green/yellow wire (3) on the Bypass contactor coil. If 36 volts are present, repair the open in the green/yellow wire. If 0 volts are found, measure the voltage at pink/orange wire (4) on the Bypass contactor coil. If 36 volts are present, replace the contactor coil. If 0 volts are present, go to Step 5.

5. Measure the voltage at pin 7 (5) of the Logic Unit with the switches and accelerator pedal in the same position as Step 2. If 36 volts are found, go to Step 6. If 0 volts are found go to Step 8.



LOGIC UNIT PINS

5. Pin 7.



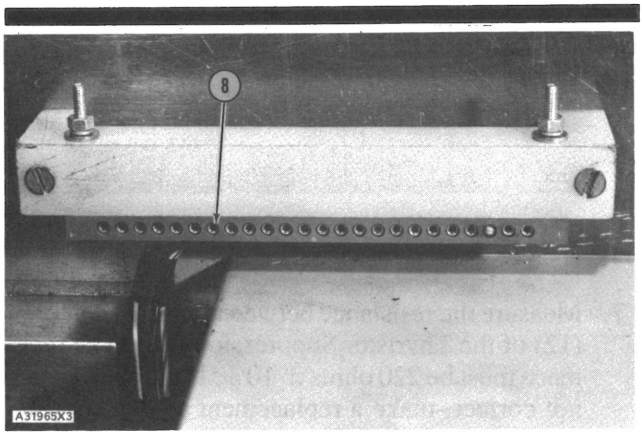
FOOT CONTROL UNIT

6. Pin 12. 7. Pin 11.

6. Disconnect the plug from the Foot Control Unit. Push the accelerator pedal completely down. Check for a complete circuit between pin 12 (6) and pin 11 (7) of the Foot Control Unit. If the circuit is not complete, adjust, repair or replace the Foot Control Unit. If the circuit is complete, go to Step 7.

⚠ WARNING

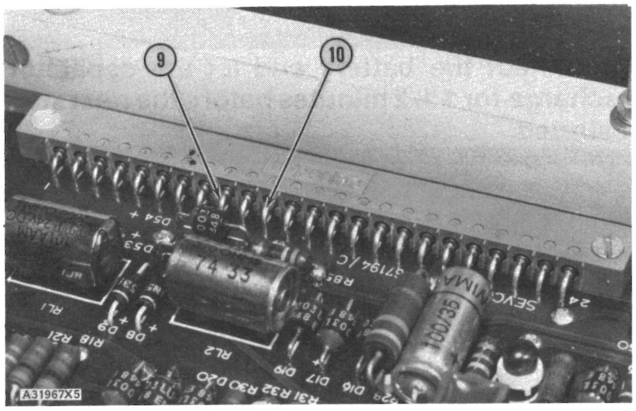
Before Step 7 is started, disconnect the battery and let the capacitor discharge for 1 1/2 minutes.



LOGIC UNIT CONNECTOR

8. Socket 7.

7. Check for a complete circuit between socket 7 (8) of the Logic Unit connector and socket 11 of the Foot Control Unit plug. Check for a complete circuit between pink/orange wire (4) at the Bypass contactor and socket 12 of the Foot Control Unit plug. Repair or replace any defective wires or connections.



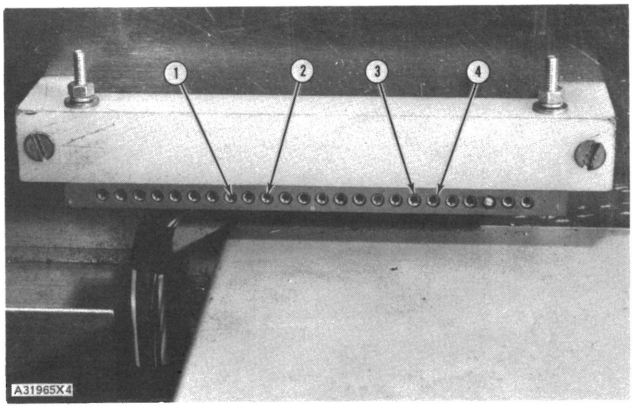
LOGIC UNIT PINS

9. Pin 9. 10. Pin 11.

8. Put the switches in the same positions as Step 2. With the Direction Switch in the FORWARD position, measure the voltage at pin 11 (10) of the Logic Unit. With the Direction Switch in the REVERSE position measure the voltage at pin 9 (9). The voltage at either pin must be 36 volts. If the voltage is not correct in forward, repair the pink wire. If the voltage is not correct in reverse, repair the brown/white wire. If the voltage is correct in both forward and reverse, repair or replace the Logic Unit.

TESTING THE THYRISTOR FIRING CIRCUIT

1. See the GENERAL INFORMATION, Voltage Checks section of TESTING AND ADJUSTING before this procedure is started.



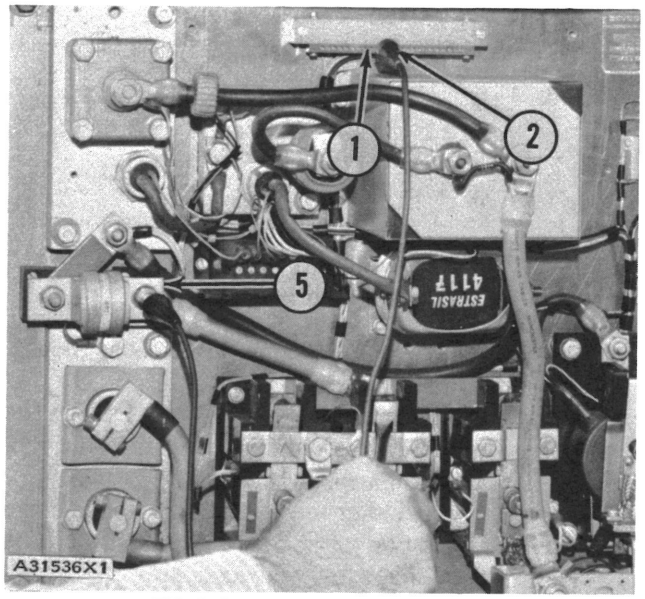
LOGIC UNIT CONNECTOR

1. Socket 8. 2. Socket 10. 3. Socket 18. 4. Socket 19.

2. Connect the red (positive) multimeter wire to socket 18 (3) of the Logic Unit connector. Connect the black (negative) wire to TH1 cathode. Manually activate one of the direction contactors. Full battery voltage must be present. If the correct voltage is present, go to Step 4. If the voltage is not present, go to Step 3.

⚠ WARNING

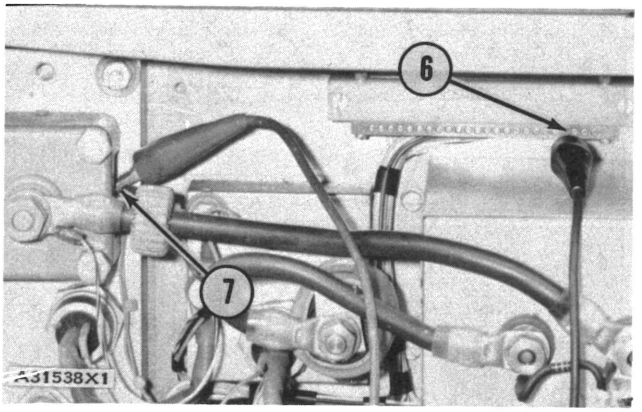
Disconnect the battery and let the capacitor discharge for 1 1/2 minutes before the next step is started.



THYRISTOR FUSE CIRCUIT TEST

1. Socket 8. 2. Socket 10. 5. Thyristor fuse.

3. Check for a complete circuit between socket 10 (2) of the Logic Unit connector and thyristor fuse (5) with the Reverse contactor manually activated. Check for a complete circuit between socket 8 (1) and the thyristor fuse with the Forward contactor manually activated. If either circuit is open, make a repair or a replacement of the parts with defects. If both circuits are complete, go to Step 4.

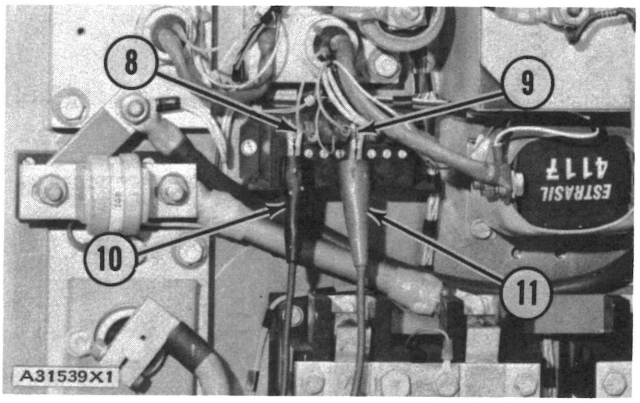


TH1 GATE CIRCUIT CHECK

6. Socket 21. 7. TH1 gate.

4. Check for a complete circuit between socket 19 (4) and the cathode of TH1. If the circuit is not complete, make the necessary repairs. If the circuit is complete, go to Step 5.

5. Check for a complete circuit between socket 21 (6) and TH1 gate (7). If the circuit is not complete, repair the brown wire. If the circuit is complete, go to Step 6.

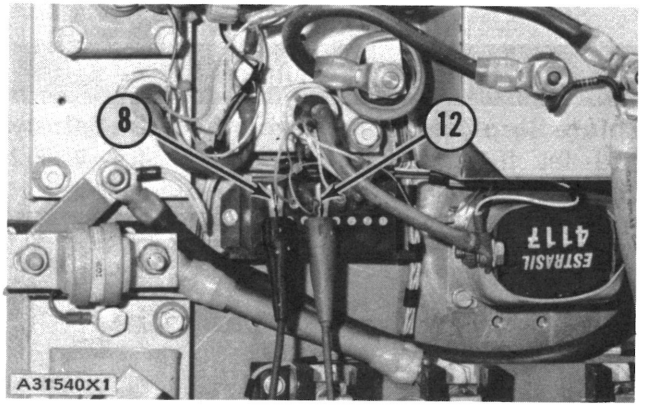


THYRISTOR SUPPRESSION UNIT

8. Pin 8. 9. Pin 4. 10. Black (negative) multimeter wire. 11. Red (positive) multimeter wire.

6. Measure the resistance between pin 8 (8) and pin 4 (9) of the Thyristor Suppression Unit. Red (positive) multimeter wire (1) must be connected to pin 4 (9) and black (negative) multimeter wire (10) must be connected to pin 8 (8).

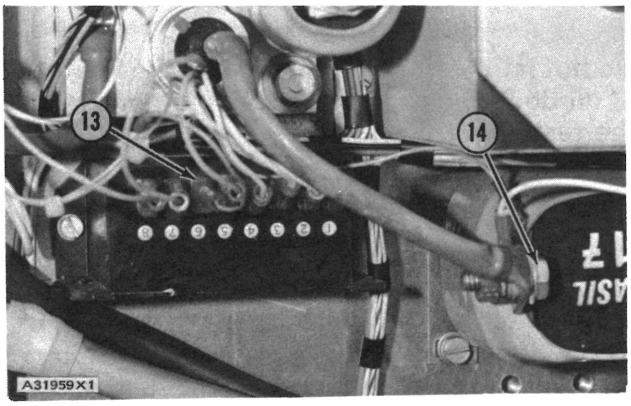
The indication must be 47 ohms plus the forward resistance of a diode. If the resistance is not correct, make a replacement of the Suppression Unit. If the resistance is correct, go to Step 7.



THYRISTOR SUPPRESSION UNIT

8. Pin 8. 12. Pin 5.

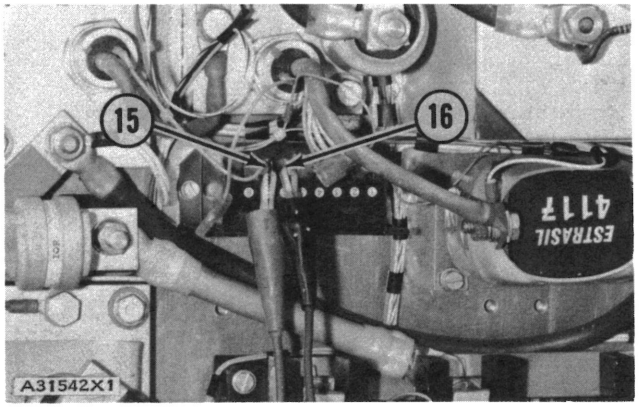
7. Measure the resistance between pin 8 (8) and pin 5 (12) of the Thyristor Suppression Unit. The resistance must be 220 ohms ± 10%. If the resistance is not correct, make a replacement of the Thyristor Suppression Unit. If the resistance is correct, go to Step 8.



CONNECTIONS FOR L3 TEST

13. Wire. 14. Terminal.

8. Disconnect wire (13) from pin 6 of the Thyristor Suppression Unit. Connect one of the multimeter wires to wire (13) and one to terminal (14) of coil L1. Check for a complete circuit between wire 13 and terminal (14). If the circuit is not complete, make a repair or a replacement of L3. If the circuit is complete, go to Step 9.

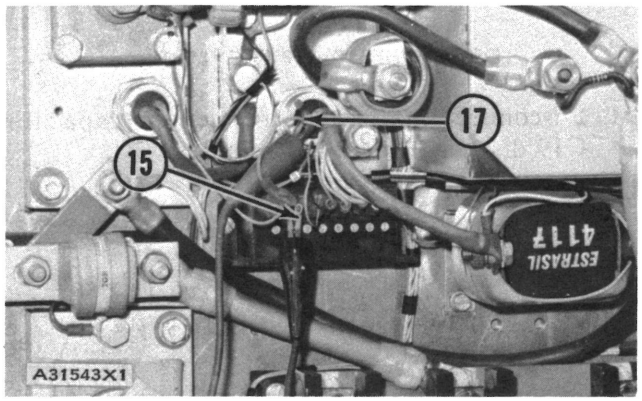


THYRISTOR SUPPRESSION UNIT

15. Pin 7. 16. Pin 6.

9. Disconnect the wires from pin 6 (16) and pin 7 (15). Check for a complete circuit between pins 6 and 7 with a multimeter. If the circuit is not complete, make a replacement of the Thyristor Suppression Unit. If the circuit is complete, go to Step 10.

10. Check for a complete circuit between pin 7 (15) of the Thyristor Suppression Unit and TH3 gate (17). Make a repair of any defects in the circuit.



TH3 GATE CIRCUIT CHECK

15. Pin 7. 17. TH3 gate.

CURRENT LIMIT ADJUSTMENT

Tools Needed: Either a 5P969 or a 2P5540 Ammeter Group can be used.

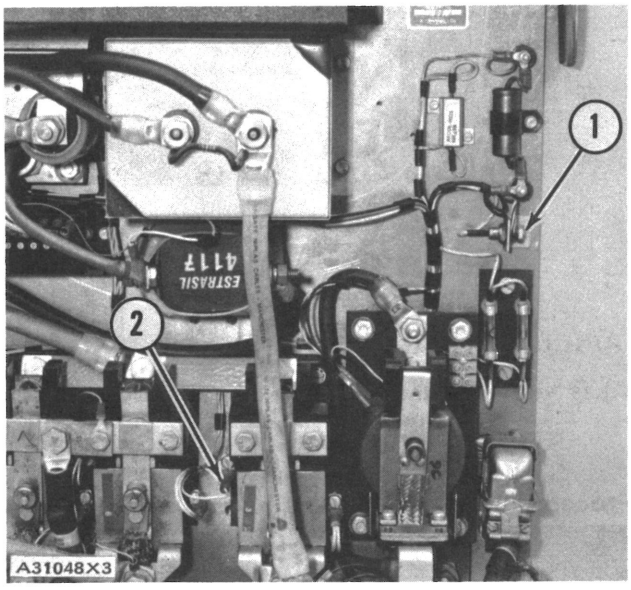
Procedure:

⚠ WARNING

Lift the front of the truck and put wood blocks safely under the frame so the drive wheels are free to turn.

DRIVE WHEELS OFF THE FLOOR

1. Disconnect the battery and let the capacitor C19 discharge for 1 1/2 minutes.



AMMETER CONNECTIONS

1. Diode D40 positive terminal. 2. Green/yellow wire on Bypass contactor coil.

2. Disconnect the green/yellow wire from the Bypass contactor coil. This prevents its operation when the foot control is fully activated.

3. If equipped with power steering, disconnect the wire for supply voltage to the PSC coil to prevent power steering motor operation during the test.

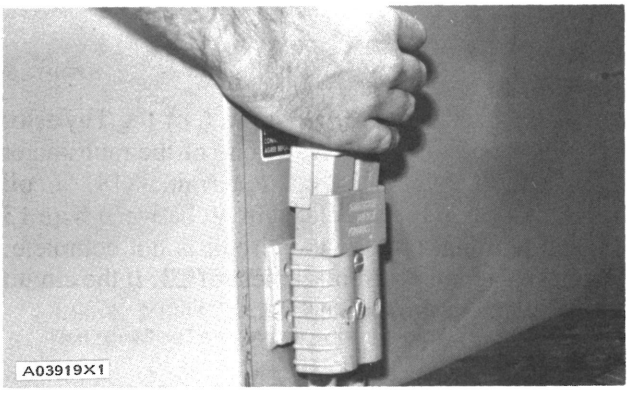
4. Connect the positive ammeter wire to D40 positive terminal (1). Connect the negative ammeter wire to the cathode of thyristor TH1.

CAUTION

Do not let the positive wire touch the heat sink of diode D40 or damage to components will be the result.

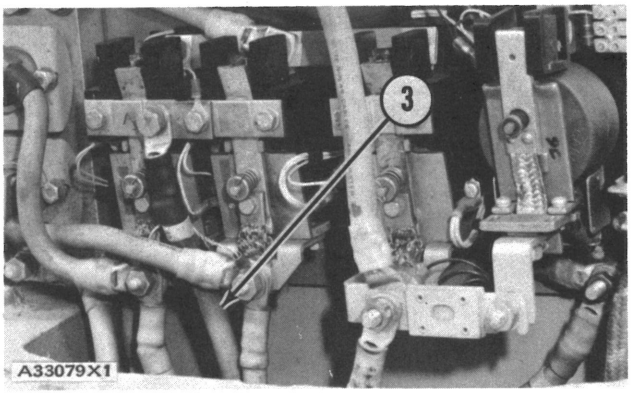
5. Connect the large clamp on the ammeter "pick-up" wire around the cable going to panel terminal A2, below the terminal strip (center connection of F-R contactors).

NOTE: Be sure the arrow on the clamp points in the direction of current flow (toward the A2 terminal).



CONNECTING BATTERY

6. Remove the cover from the Logic Unit.



CURRENT PICK-UP LOCATION

3. Cable A2.

7. Connect the battery.

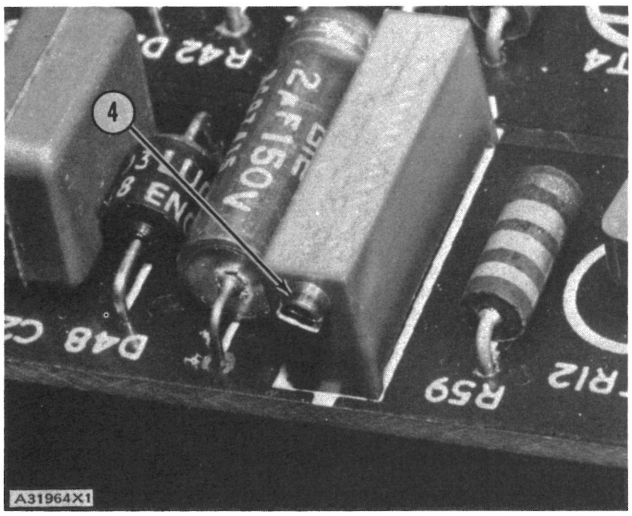
8. Put the direction control lever in the FORWARD position.

9. Activate the brake pedal so the drive wheels can not turn.

10. Push the accelerator pedal all the way down and make note of the ammeter indication.

ACCELERATOR AND BRAKE PEDALS ACTIVATED

11. Allow the accelerator pedal to come back slowly. Pulsing will start suddenly at full rate. Hold the pedal at full rate point and adjust VR3 adjustment screw (4) for current limit as fast as possible.
    a. Current limit for 36/48 volt trucks is 450 amps.
    b. Current limit for 72/80 volt trucks is 350 amps.



CURRENT LIMIT ADJUSTMENT
4. VR3 adjustment screw.

CAUTION

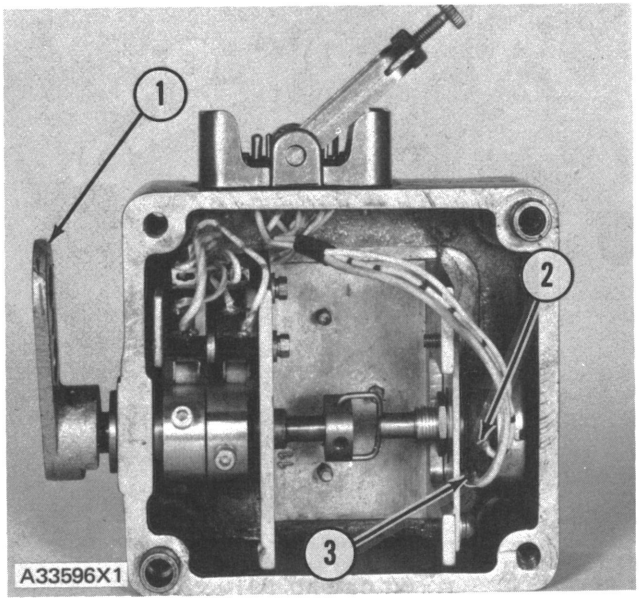
Do not stall the drive wheels for more than 30 seconds at a time. Let the drive motor have time to become cool between stalls. Never turn current limit potentiometer VR3, farther than necessary for an adjustment.

NOTE: The 5P969 Ammeter Group has two ranges: 0-500 amp and 0-1500 amp. Use the highest range to make the adjustments and the 0-500 amp range for the final check. The 2P5540 Ammeter Group also has two ranges; use the highest range for the test.

12. After correct adjustment has been made, remove the ammeter from the panel.
13. Connect the wire to the By-Pass contactor terminal. Connect wire to power steering contactor coil (if equipped).
14. Install the cover on the Logic Unit.

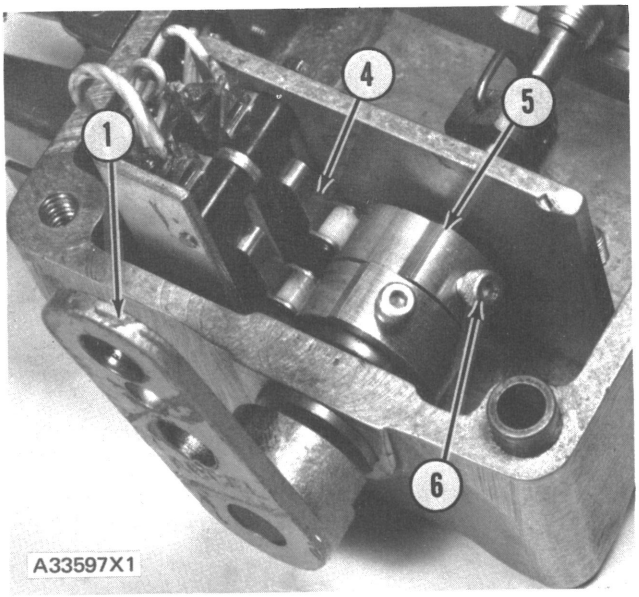
FOOT CONTROL UNIT ADJUSTMENT

1. Remove the Foot Control Unit from the truck.



FOOT CONTROL UNIT
1. Lever. 2. Terminal 2. 3. Terminal 3.

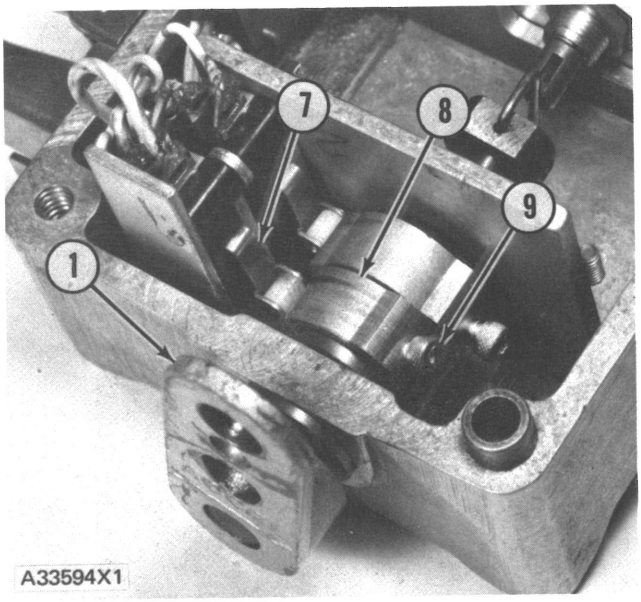
2. Connect the multimeter wires to terminals 2 (2) and 3 (3). Use the RX100 scale.
3. Turn the Foot Control Unit lever (1) completely counterclockwise.



REAR CAM ADJUSTMENT

1. Lever. 4. Microswitch. 5. Rear cam. 6. Screw.

4. Turn lever (1) slowly clockwise until the resistance just starts to increase. Loosen screw (6) and adjust rear cam (5) until microswitch (4) activates just before the resistance starts to increase. Tighten screw (6) to hold the cam in position.



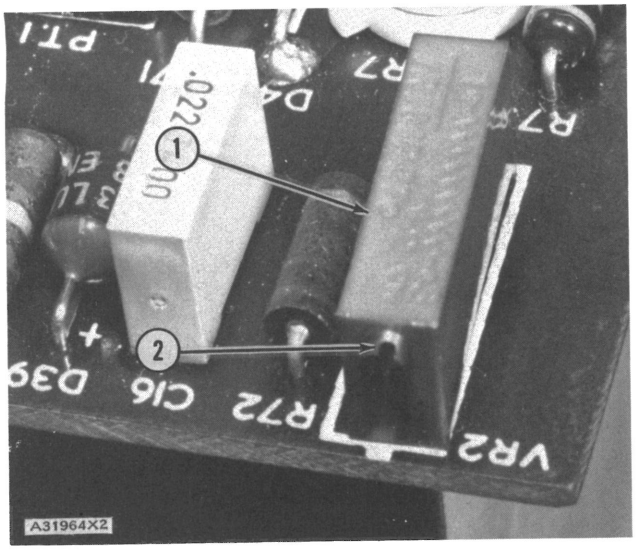
FRONT CAM ADJUSTMENT

1. Lever. 7. Microswitch. 8. Front cam. 9. Screw.

5. Turn lever (1) clockwise until maximum resistance is indicated on the multimeter.

6. Loosen screw (9), adjust front cam (8) until microswitch (7) activates just as the resistance becomes maximum. Tighten screw (9) to hold the cam in position.

PLUGGING DISTANCE ADJUSTMENT



PLUGGING ADJUSTMENT

1. VR2. 2. Adjustment screw.
(Logic Unit cover removed)

1. Adjustment screw (2) which is part of VR2 (1) in the Logic Unit, can be turned to adjust the plugging distance to the operator's preference.

⚠ WARNING

Make sure the test is made in a safe area and on a clean level surface. When the plugging distance is checked with a load, be sure the load is safe on the forks.

Conditions:

a) Truck must be 'warmed up' to normal temperature of operation and have normal capacity load.

b) Put a mark on the ground or floor surface for a plugging start location.

c) The correct plugging stop distance is dependent on the maximum bypass speed.

d) The kind of load to be handled also depends on the plugging distance adjustment.

Procedure:

e) Move the truck in FORWARD direction at full speed. Change the direction lever to the REVERSE position (accelerator pedal still fully depressed). Measure the distance to the point where the truck stops completely before it moves in REVERSE.

Adjust plugging distance at VR2 as follows: (Tolerance is ± 10%)

6 mph — 12 to 20 ft. (3.7 to 6.1 m)

8 mph — 21 to 35 ft. (6.4 to 10.7 m)

NOTE: Counterclockwise rotation will increase distance, and clockwise rotation will make the distance less.

CAUTION

Do not let the plugging distance be less than that recommended. Anything less can cause an excessive load and heat, and can damage the drive motor.

OPERATION TEST FOR THYROSTOP MODULE

1. Disconnect Battery.
2. Disconnect Red wire from Thyrostop Module, from lower H.B. pump contactor power terminal. Reconnect battery.
3. Close key switch and seat or hand brake switch. Hold the Red wire carefully so that it makes contact with the terminal from which it has just been removed. Close the valve microswitch and let the pump motor finish its accelerating sequence. Remove the Red wire from its contact with the H.B. contactor. The H.B. contactor should now drop out.
4. Keep the valve microswitch closed and carefully touch the Red wire to the above mentioned terminal. The contactor should remain open.
5. If the H.B. contactor fails to drop out or if it re-closes when the contact is touched by the Red wire, replace the Thyrostop Module.

SPECIFICATIONS

COMPONENT OR CIRCUIT	SIMPSON METER SCALE	METER POSITIVE CABLE	METER NEGATIVE CABLE	DESIRED INDICATION
COILS L1 and L2				
RESISTANCE INDICATION– CENTER CABLE AND WIRE REMOVED	RX1	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	0 ohms
CAPACITOR BANK C19				
RESISTANCE INDICATION	RX10,000	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	0 and then swing to above 100,000 ohms
THYRISTORS				
RESISTANCE INDICATION– CATHODE & GATE LEADS REMOVED	RX100	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING
POWER DIODES D41-D42				
RESISTANCE INDICATION	RX1	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING
MAIN VOLTAGE–LOGIC UNIT				
VOLTAGE INDICATION	50V D.C.	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	18 volts
RESISTANCE INDICATIONS	RX100	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING
SECONDARY VOLTAGE–LOGIC UNIT				
VOLTAGE INDICATION	50V D.C.	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	9 volts
RESISTANCE INDICATIONS	RX100	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING
DIRECTION CONTACTOR COILS				
VOLTAGE INDICATIONS	50V D.C.	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	36 volts
RESISTANCE INDICATIONS	RX1	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	38 to 45 ohms

SPECIFICATIONS

COMPONENT OR CIRCUIT	SIMPSON METER SCALE	METER POSITIVE CABLE	METER NEGATIVE CABLE	DESIRED INDICATION
BY-PASS CONTACTOR COIL				
VOLTAGE INDICATION	50V D.C.	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	36 volts
RESISTANCE INDICATION	RX1	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	38 to 45 ohms
THYRISTOR FIRING CIRCUIT				
VOLTAGE INDICATION– DIRECTION CONTACTOR ACTIVATED	250V D.C.	PIN 10 OF LOGIC UNIT PLUG	CATHODE OF NO. 1 THYRISTOR	Battery Volts
RESISTANCE INDICATIONS	RX1	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	0 ohms
FOOT CONTROL POTENTIOMETER				
RESISTANCE INDICATIONS	RX100	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING	see TESTING AND ADJUSTING
CURRENT LIMIT				
MAXIMUM AMPS (VR3 Potentiometer on Logic Card)	Use 5P969 Ammeter	See TESTING AND ADJUSTING	See TESTING AND ADJUSTING	36/48 Volt Trucks 450 Amps
				*72/80 Volt Trucks 350 Amps
RESISTANCE AGAINST FRAME				
NEW TRUCK	RX 10,000	To connector leads — panel side	To good (clean) Frame connection	More than 20,000 ohms
USED TRUCK				More than 10,000 ohms

BRUSHES

Drive Motors

36-48 Volt Trucks:

Brush 3C2573

Length (new) ..... 1.80 in. (45.8 mm)
Minimum length ..... .67 in. (17 mm)
Width ..... 1.58 in. (40 mm)
Thickness ..... .63 in. (16 mm)

72-80 Volt Trucks:

Brush 3C2518

Length (new) ..... 1.80 in. (45.8 mm)
Minimum length ..... .67 in. (17 mm)
Width ..... 1.58 in. (40 mm)
Thickness ..... .50 in. (12.5 mm)

Hydraulic Pump Motors

36-48 Volt Trucks:

Brush 3C2507

Length (new) ..... 1.61 in. (40.8 mm)
Minimum length ..... .61 in. (17 mm)
Width ..... 1.58 in. (40 mm)
Thickness ..... .50 in. (12.5 mm)

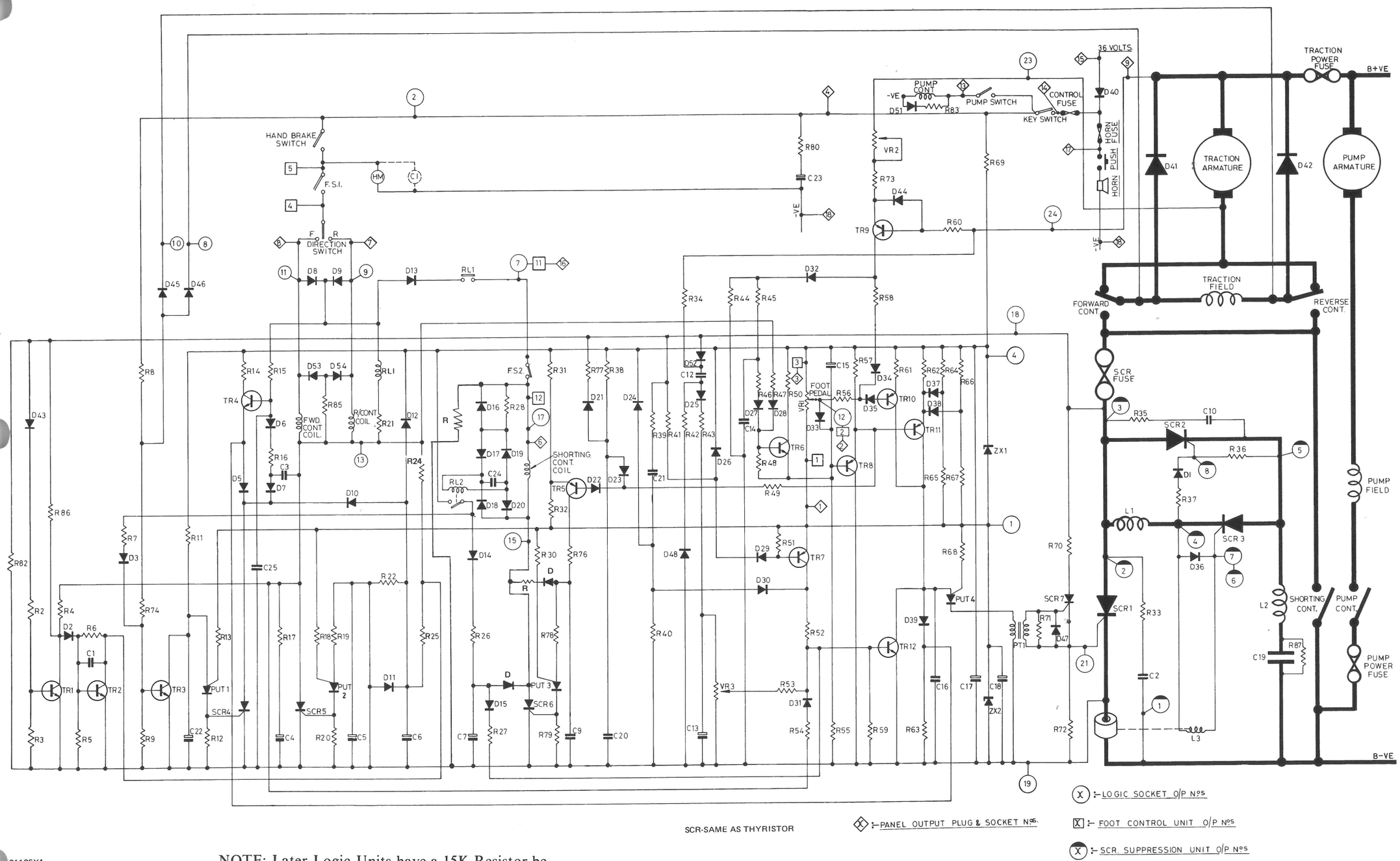
72-80 Volt Trucks:

Brush 3C2548

Length (new) ..... 1.61 in. (40.8 mm)
Minimum length ..... .67 in. (17 mm)
Width ..... 1.58 in. (40 mm)
Thickness ..... .40 in. (10 mm)

M20, M25, MC30
SCR CONTROL SYSTEM

SCHEMATIC WITH LOGIC UNIT



SCR-SAME AS THYRISTOR

◇ :- PANEL OUTPUT PLUG & SOCKET Nos.

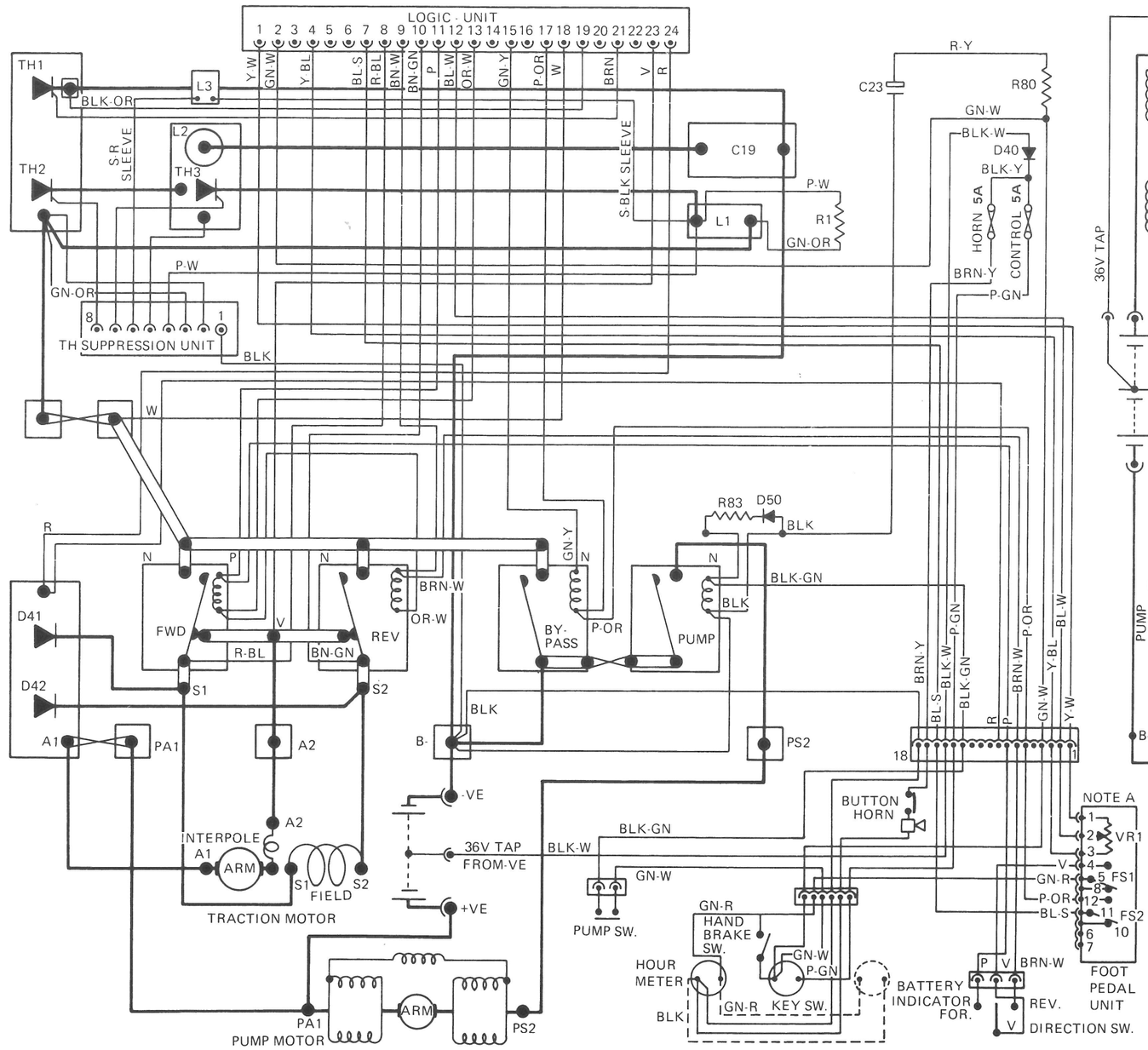
(X) :- LOGIC SOCKET O/P Nos

[X] :- FOOT CONTROL UNIT O/P Nos

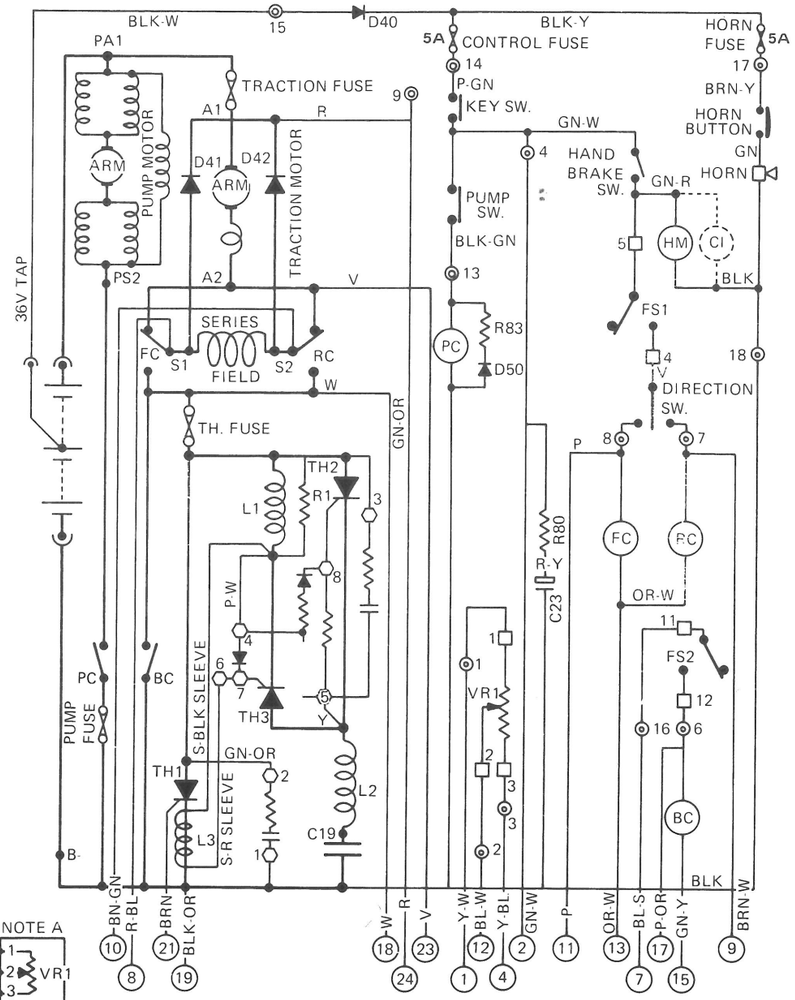
(X) :- SCR. SUPPRESSION UNIT O/P Nos

NOTE: Later Logic Units have a 15K Resistor between R63 at Logic Socket (15) and B–. Also, Resistor (R) is removed from Foot Control Unit Connection [12] and B–.

WIRING DIAGRAM



SCHEMATIC

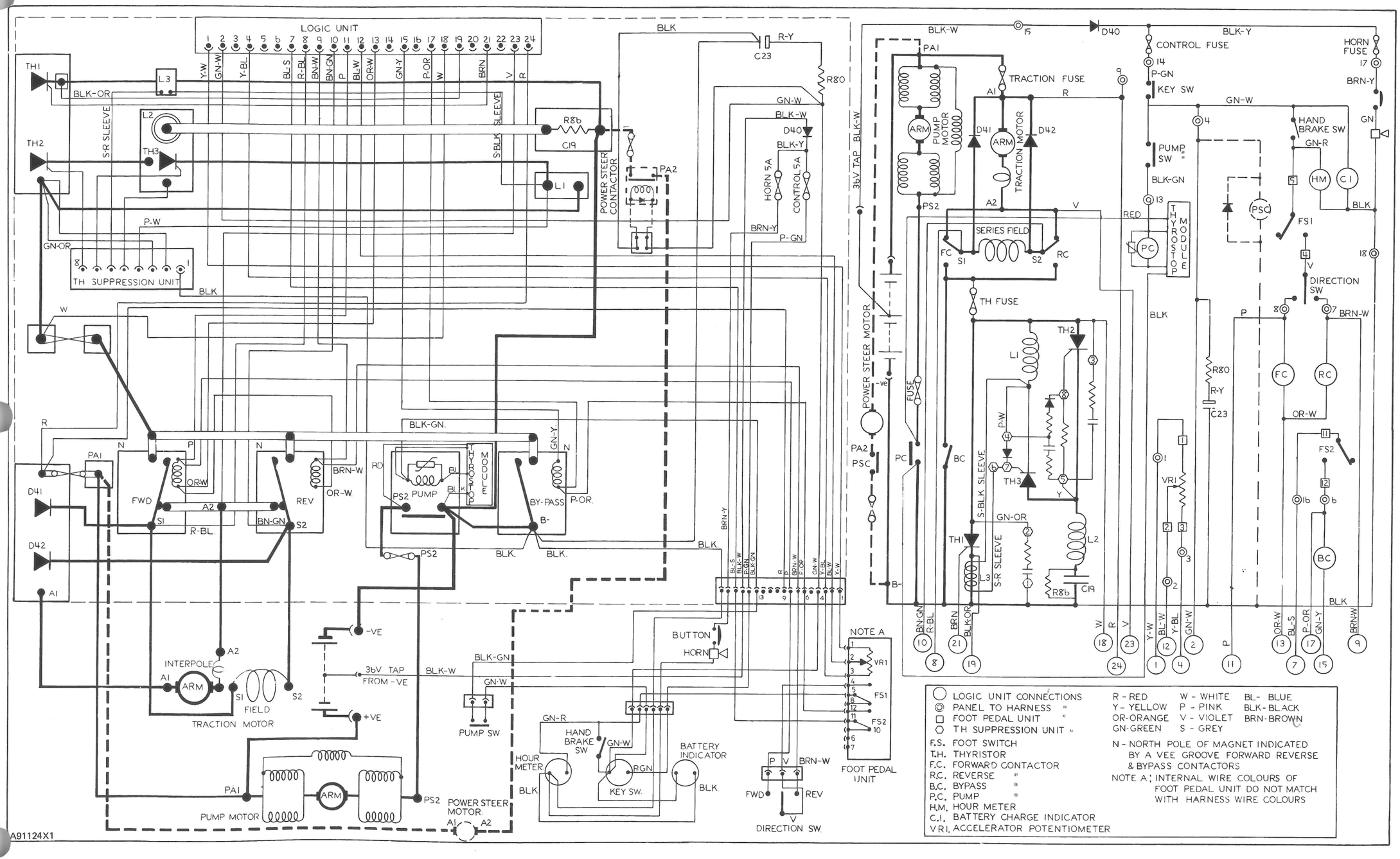


○	LOGIC UNIT CONNECTIONS	R –	RED	W –	WHITE	BL –	BLUE
◎	PANEL TO **HARNESS CONNECTIONS**	Y –	YELLOW	P –	PINK	BLK –	BLACK
□	FOOT PEDAL UNIT CONNECTIONS	OR –	ORANGE	V –	VIOLET	BRN –	BROWN
○	**TH. SUPPRESSION UNIT CONNECTIONS**	GN –	GREEN	S –	GREY		
F.S.	FOOT SWITCH						
TH.	THYRISTOR						
FC	FORWARD CONTACTOR	N – NORTH POLE OF MAGNET INDICATED BY A RED DOT					
RC	REVERSE CONTACTOR						
BC	BYPASS CONTACTOR						
PC	PUMP CONTACTOR	NOTE A: INTERNAL WIRE COLOURS OF FOOT PEDAL UNIT DO NOT MATCH WITH HARNESS **WIRE** COLOURS					
HM	HOUR METER						
CI	BATTERY CHARGE INDICATOR						
VR1	ACCELERATOR POTENTIOMETER						

33598X1

WIRING DIAGRAM

SCHEMATIC



(CURRENT MODEL LIFT TRUCKS)

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FORM NO. SENB8038-01

SEPTEMBER 1985
PRINTED IN U.S.A.